

# Waterford Public Schools

## Grades 6-12 Science Curriculum

Earth & Space Science  
Anatomy & Physiology  
Physical Science  
Biology  
Environmental Science  
Marine Biology

Life Science

Physics

Chemistry

Revised 2015

# TABLE OF CONTENTS

Revision Committee .....	1
Grade 6: Earth and Space Science .....	2
Grade 7: Life Science.....	22
Grade 8: Physical Science.....	48
Grades 9-12: Overview .....	69
Grades 9-11: Earth and Space Science Courses 1 & 2.....	75
Grades 9-11: Life Science Courses 1 & 2.....	97
Grades 9-11: Physical Science Courses .....	118
Chemistry for Future Presidents / Chemistry I - H.....	123
The Chemistry and Physics of Forensics .....	133
Physics for Future Presidents - A / Physics I - H.....	148
Chemistry II - H.....	159
AP Physics II - H.....	167
Environmental Science - S.....	187
AP Environmental Science - H.....	204
Anatomy and Physiology - A .....	222
Anatomy and Physiology - H.....	239
UConn ECE Biology .....	260
AP Chemistry - H .....	298
AP Physics III - H .....	338
Marine Biology - S.....	383
Marine Biology I - A - Marine Ecosystems .....	391
Marine Biology II - A - Marine Organisms .....	401
UConn ECE Marine Science - H.....	410

## **REVISION COMMITTEE**

### **Clark Lane Middle School**

Olivia Turowski, Curriculum Leader

Kimberly Agins

Kenneth Daniewicz

Christopher McNeil

### **Waterford High School**

Amanda Batty, Department Chairperson

Tessa Castleberry

Katherine Grobsky

Diane Herr

Todd Kane

Gina Lecco

James Lovering

Michael O'Connor

Dawn Poitras

Barbara Rafferty

## **GRADE 6 EARTH AND SPACE SCIENCE**

In sixth grade students will focus on Earth Sciences. The focus will be on the big ideas of Earth's place in the universe, Earth's systems and Earth and human activity. In Earth's place in the universe the emphasis will be how and why Earth is constantly changing and how people reconstruct and date events in Earth's planetary history. In Earth's systems, the emphasis is how and why Earth is constantly changing. In Earth and human activity the emphasis is how geologic processes and human activity have impacted Earth.

## **GRADE 6 EARTH AND SPACE SCIENCE**

### **UNIT 1: EARTH'S PLACE IN THE UNIVERSE**

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-ESS1-1, MS-ESS1-2)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to provide evidence for phenomena. (MS-ESS1-3)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS1-4)

#### **CROSSCUTTING CONCEPTS**

##### **Patterns**

- Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3)

##### **Scale Proportion and Quantity**

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4, MS-ESS2-2)

##### **Systems and System Models**

- Models can be used to represent systems and their interactions. (MS-ESS1-2)

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 1: EARTH'S PLACE IN THE UNIVERSE

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation' (MS-ESS1-1, MS-ESS1-2)

#### **CONNECTION TO ENGINEERING, TECHNOLOGY, AND APPLICATION OF SCIENCE**

##### **Interdependence of Science, Engineering, and Technology**

- Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS 1-3)

#### **COMMON CORE**

##### ***ELA/Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3, MS-ESS1-4)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS1-3)
- HST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4)
- SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest (MS-ESS1-1, MS-ESS1-2)

##### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (MS-ESS1-3)
- MP.4** Model with mathematics. (MS-ESS1-1, MS-ESS1-2)
- 6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-1, MS-ESS1-2, MS-ESS1-3)
- 7.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-ESS1-1, MS-ESS1-2, MS-ESS1-3)
- 6.EE.B.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-2, MS-ESS1-4)
- 7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS1-2, MS-ESS1-4)

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 1: EARTH'S PLACE IN THE UNIVERSE

*How and why is Earth constantly changing and how do people reconstruct and date events in Earth's planetary history?*

MS-ESS1.A: The Universe and Its Stars

MS-ESS1.B: Earth and the Solar System

MS-ESS1.C: The History of Planet Earth

#### **OBJECTIVES: (PERFORMANCE EXPECTATIONS)**

**MS-ESS1-1:** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (examples of models can be physical, graphical, or conceptual) **S&EP: Developing and using models**

**MS-ESS1-2:** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth. **S&EP: Developing and using models**

**MS-ESS1-3:** Analyze and interpret data to determine scale properties of objects in the solar system. Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models. Does not include recalling facts about properties of the planets and other solar system bodies. **S&EP: Analyzing and Interpreting Data**

**MS-ESS1-4:** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions. Does not include recalling the names of specific periods or epochs and events within them. **SE&P: Constructing explanations and designing solutions**

#### **Essential Questions**

MS-ESS1.A: What is the Universe and what goes on in stars?

MS-ESS1.B: What are the predictable patterns caused by Earth's movement in the solar system?

MS-ESS1.C: How do people reconstruct and date events in Earth's planetary history?

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 1: EARTH'S PLACE IN THE UNIVERSE**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ESS1.A: The Universe and Its Stars</b></p> <ul style="list-style-type: none"> <li>• Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.</li> <li>• Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.</li> </ul> <p><b>ESS1.B: Earth and the Solar System</b></p> <ul style="list-style-type: none"> <li>• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.</li> <li>• This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.</li> <li>• The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.</li> </ul> <p><b>ESS1.C: The History of Planet Earth</b></p> <ul style="list-style-type: none"> <li>• The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• MyScience8.com</li> <li>• Labs or demonstrations using model globes and flashlights to demonstrate motion of sun, moon, and Earth during seasons, moon phases, eclipses, etc.</li> <li>• Use of Powers of 10 video/YouTube to demonstrate scale of universe</li> <li>• Labs or demonstrations of fossils and rock strata</li> <li>• Earth Model project</li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim.</li> <li>• Projects</li> <li>• End of unit assessment</li> <li>• 2 Minute experts: oral presentations for a given topic</li> </ul>



**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 1: EARTH'S PLACE IN THE UNIVERSE**

**RESOURCES**

- Key Concept Words:
  - force, gravity, orbit, revolve, year, period, mass, weight, rotate, hemisphere, season, lunar phases, satellite, solar eclipse, lunar eclipse, tide, fossil, strata, galaxy, asteroid, geologic time scale
- Books/Magazines:
  - NSTA *Science Scope*; *Scholastic Science*
- Videos/Promethean Board:
  - **DVD:** Bill Nye titles: The Planets; Comets and Meteors; Outer Space; The Moon; The Sun; Disney titles: Gravity,, Mars Dead or Alive; Nat Geo titles: Journey to the Edge of the Universe;
  - **VHS** – Space Science in Action: Planets and the Solar System
  - **Promethean Board: New Path Learning:** The Sun-Earth-Moon System
- Equipment/Supplies:
  - Styrofoam moon phases, solar system science cards and information sheets, light globe, star and planet locator (constellations), solar system model, Eloquent Earth demonstration for overhead, Earth-Moon-Sun exploration kit, the Season Cycler kit, Constructing a moon phase kit, *The Astronomy Fact Book*, Space Hop Game –for planets, Lunar cycle chart, Spacepology Game (2), hanging Solar Mobile, centripetal force apparatus, fossils, adding machine tape

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 2: EARTH'S SYSTEMS

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-ESS2-1), (MS-ESS2-6)
- Develop a model to describe unobservable mechanisms. (MS-ESS2-4)

##### **Planning and Carrying Out Investigations**

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS2-3)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS2-2)

#### **CROSSCUTTING CONCEPTS**

##### **Patterns**

- Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3)

##### **Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 2: EARTH'S SYSTEMS

#### Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS2-2)

#### Systems and System Models

- Models can be used to represent systems and their interactions – such as inputs, processes and outputs- and energy, matter, and information flows within systems. (MS-ESS2-6)

#### Energy and Matter

- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

#### Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)

### CONNECTIONS TO NATURE OF SCIENCE

#### Scientific knowledge is Open to Revision in Light of New Evidence

- Science findings are frequently revised and/or reinterpreted based on new evidence.

### COMMON CORE

#### *ELA/Literacy*

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-1)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3)
- RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3, MS-ESS 2-5)
- WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS3-1)
- WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.(MS-ESS2-5)

## **GRADE 6 EARTH AND SPACE SCIENCE**

### **UNIT 2: EARTH'S SYSTEMS**

**SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS2-1)

#### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (MS-ESS 2-2, MS-ESS 2-3, MS-ESS 2-5)

**6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real world contexts, explaining the meaning of 0 in each situation. (MS-ESS 2-5)

**6.EE.B.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-1)

**7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-1)

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 2: EARTH'S SYSTEMS

*How and why is Earth constantly changing?*

**Core Ideas MS-ESSA & MS-ESS3: Earth's Systems (CT 6.4)**

MS-ESS1.C: The History of Earth

MS-ESS2.A: Earth's Materials and Systems

MS-ESS2.B: Plate Tectonics and Large-Scale System Interactions

MS-ESS2.C: The Role of Water in Earth's Surface Processes

MS-ESS2.D: Weather and Climate

#### **Objectives: (Performance Expectations)**

**MS-ESS2-1:** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. Does not include the identification and naming of minerals. **S&EP: Developing and Using Models**

**MS-ESS2-2:** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate. **SE&P: Constructing explanations and designing solutions**

**MS-ESS2-3:** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches). Does not include Paleomagnetic anomalies in oceanic and continental crust. **SE&P: Analyzing and interpreting data**

**MS-ESS 2-4:** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical. Not to include a quantitative understanding of the latent heats of vaporization and fusion. : **S&EP: Developing and Using Models**

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 2: EARTH'S SYSTEMS**

**MS-ESS2-5:** Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] **SE&P: Asking Questions and Defining Problems**

**MS-ESS2-6:** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations. **SE&P: Developing and Using Models**

**Essential Questions**

MS-ESS1.C: How do people reconstruct and date events in Earth’s planetary history?

MS-ESS2.A: How do Earth’s major systems interact?

MS-ESS2.B: Why do continents move, and what causes earthquakes and volcanoes?

MS-ESS2.C: How do the properties and movements of water shape Earth’s surface and affect its systems?

MS-ESS2.D: What regulates weather and climate?

Disciplinary Core Ideas (DCI’s) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ESS1.C: The History of Planet Earth</b></p> <ul style="list-style-type: none"> <li>Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.</li> </ul> <p><b>ESS2.A: Earth’s Materials and Systems</b></p> <ul style="list-style-type: none"> <li>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycle produce chemical and physical changes in Earth’s materials and living organisms.</li> </ul>	<ul style="list-style-type: none"> <li>Outlining/note taking</li> <li>Identifying text structures</li> <li>Summarizing and or paraphrasing text</li> <li>Annotation</li> <li>Graphic organizers</li> <li>Peer editing</li> <li>Guided writing lessons</li> </ul>	<ul style="list-style-type: none"> <li>Vocabulary check for understanding</li> <li>Content tests and quizzes</li> <li>Document based question responses</li> <li>Participation in class discussions</li> <li>Summaries of various sources</li> </ul>

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 2: EARTH'S SYSTEMS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.</li> </ul> <p><b>ESS2.B: Plate Tectonics and Large-Scale System Interactions</b></p> <ul style="list-style-type: none"> <li>• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.</li> </ul> <p><b>ESS2.C: The Roles of Water in Earth's Surface Processes</b></p> <ul style="list-style-type: none"> <li>• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.</li> <li>• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.</li> <li>• Global movements of water and its changes in form are propelled by sunlight and gravity.</li> <li>• Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.</li> <li>• Water's movements-both on the land and underground-cause weathering and erosion, which change the land's surface features and create underground formations.</li> </ul>	<ul style="list-style-type: none"> <li>• Use of common rubrics across discipline</li> <li>• Use of models to demonstrate tectonic movement</li> <li>• Geologic time scale</li> <li>• Heating of Earth's surface lab:               <ul style="list-style-type: none"> <li>○ Radiation, convection &amp; condensation</li> </ul> </li> <li>• Project Wet:               <ul style="list-style-type: none"> <li>○ Incredible journey p. 155</li> </ul> </li> <li>• Water cycle:               <ul style="list-style-type: none"> <li>○ Watch video clip</li> </ul> </li> <li>• Diagram water cycle:               <ul style="list-style-type: none"> <li>○ Project Wet – Just passing through p. 163</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Reader responses requiring students to use single and multiple sources to support their claim.</li> <li>• Projects</li> <li>• End of unit assessment</li> </ul>

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 2: EARTH'S SYSTEMS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ESS2.D: Weather and Climate</b></p> <ul style="list-style-type: none"> <li>• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.</li> <li>• Because these patterns are so complex, weather can only be predicted probabilistically.</li> <li>• The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through the ocean currents.</li> </ul>		

**RESOURCES**

- Key Concept Words:
  - surface water, ground water, fresh water, salt water, pollutant, watershed, point source pollution, nonpoint source pollution, well, septic system, wastewater, oceans, lakes, currents, convection currents, air mass, weather, climate, front, evaporation, condensation, transpiration, precipitation, crystallization, latitude, altitude, erosion, weathering, fossil, plate tectonics, Pangea, subduction, convergent boundaries, divergent boundaries, transform boundaries, earthquake, volcanos, trench, mid-ocean ridge, mountains, faults, seismic waves, Richter Scale, tsunamis, magma, lava, basalt, silica, hot spots
- Books/magazines:
  - NSTA Science Scope; Scholastic Science
- Videos/Promethean Board:
  - **DVD:** Bill Nye: Water Cycle ; Gravity; Disney Education: Gravity; Earth Science: Fossil Fuels; Natural Resources; Minerals; Eye Witness: Natural Disasters
  - **DVD: Bill Nye:** Water Cycle, Bill Nye: Gravity, Earth Science: Natural Sciences, Earth Science: Minerals, Earth Science: Fossil Fuel; Storms; Water Cycle; Pressure; **Disney Education:** Gravity, Earth Science: Natural Resources
  - **Promethean Board: New Path Learning:** Earth's Climate; Earth's Atmosphere & Weather; Plate Tectonics; Earth's Surfaces
- Equipment/Supplies
  - Models of plate tectonics, fault models, erosion table, weathering and erosion supplies, fossils, rock samples



## **GRADE 6 EARTH AND SPACE SCIENCE**

### **UNIT 3: EARTH AND HUMAN ACTIVITY**

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Asking Questions and Defining Problems**

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS3-2)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Constructing a scientific explanation based on valid and reliable evidence obtained from sources (including students- own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.) (MS-ESS 3-1).
- Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

##### **Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

#### **CROSSCUTTING CONCEPTS**

##### **Patterns**

Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

##### **Cause and Effect**

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)

## **GRADE 6 EARTH AND SPACE SCIENCE**

### **UNIT 3: EARTH AND HUMAN ACTIVITY**

#### **Stability and Change**

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### **Science Addresses Questions About the Natural and Material World**

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)

#### **CONNECTIONS TO ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

##### **Influence of Science, Engineering, and Technology on Society and the Natural World**

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-4)
- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2, MS-ESS3-3)

#### **COMMON CORE**

##### ***ELA/Literacy***

**RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-2, MS-ESS3-4)

**RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2)

**WHST.6-8.1** Write arguments focused on discipline content. (MS-ESS3-4)

**WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content (MS-ESS 3-1)

**WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ESS3-3)

**WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3)

**WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-4)

## **GRADE 6 EARTH AND SPACE SCIENCE**

### **UNIT 3: EARTH AND HUMAN ACTIVITY**

#### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (MS-ESS3-2)
- 6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3, MS-ESS3-4)
- 7.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-ESS3-3, MS-ESS3-4)
- 6.EE.B.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-2, MS-ESS3-3, MS-ESS3-4)
- 7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-2, MS-ESS3-3, MS-ESS3-4)

## GRADE 6 EARTH AND SPACE SCIENCE

### UNIT 3: EARTH AND HUMAN ACTIVITY

*How do Earth's surface processes and human activities affect each other?*

**Core Ideas MS-ESS2 & MS-ESS3: Weather and Climate (CT 6.4)**

ESS3.A: Natural Resources

ESS3.B: Natural Hazards

ESS3.C: Human Impacts on Earth Systems

ESS3.D: Global Climate Change

#### **Objectives: (Performance Expectations)**

**MS-ESS 3-1:** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).] **S&EP: Constructing Explanations and Designing Solutions**

**MS-ESS 3-2:** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Emphasis on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts) **S&EP: Analyzing and Interpreting Data**

**MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.\* Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land). **S&EP: Constructing Explanations and Designing Solutions**

## GRADE 6 EARTH AND SPACE SCIENCE UNIT 3: EARTH AND HUMAN ACTIVITY

**MS-ESS3-4:** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes. **S&EP: Constructing Explanations and Designing Solutions**

**MS-ESS3-5:** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures. **SE&P: Asking Questions and Defining Problems**

### Essential Questions

MS-ESS3.A: How do humans depend on Earth's resources?

MS-ESS3.B: How do natural hazards affect individuals and societies?

MS-ESS3.C: How do humans change the planet?

MS-ESS3.D: How do people model and predict the effects of human activity on Earth's climate?

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ESS3.A: Natural Resources</b></p> <ul style="list-style-type: none"> <li>Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.</li> </ul> <p><b>ESS3.B: Natural Hazards</b></p> <ul style="list-style-type: none"> <li>Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.</li> </ul>	<ul style="list-style-type: none"> <li>Outlining/note taking</li> <li>Identifying text structures</li> <li>Summarizing and or paraphrasing text</li> <li>Annotation</li> <li>Graphic organizers</li> <li>Peer editing</li> <li>Guided writing lessons</li> </ul>	<ul style="list-style-type: none"> <li>Vocabulary check for understanding</li> <li>Content tests and quizzes</li> <li>Document based question responses</li> <li>Participation in class discussions</li> <li>Summaries of various sources</li> </ul>

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 3: EARTH AND HUMAN ACTIVITY**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ESS3.C: Human Impacts on Earth Systems</b></p> <ul style="list-style-type: none"> <li>• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.</li> <li>• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.</li> </ul> <p><b>ESS3.D: Global Climate Change</b></p> <ul style="list-style-type: none"> <li>• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Brainstorming ideas for designs</li> <li>• Use of common rubrics across discipline</li> <li>• Project Need</li> </ul>	<ul style="list-style-type: none"> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> </ul>

**GRADE 6 EARTH AND SPACE SCIENCE  
UNIT 3: EARTH AND HUMAN ACTIVITY**

**RESOURCES**

- Key Concept Words:
  - surface water, ground water, fresh water, salt water, pollutant, watershed, point source pollution, non-point source pollution, well, septic system, wastewater, atmosphere, biosphere, global warming, climate, earthquake, hurricane, tornado, tsunami, renewable resources, non-renewable resources, habitat, oil, natural gas, fossil fuels, greenhouse gases, faults, seismic waves, epicenter, Richter scale, seismograph
- Books/magazines:
  - NSTA Science Scope; Scholastic Science
- Videos/Promethean Board:
  - **DVD:** Eyewitness: Natural Disaster; Nova: Mystery of Megavolcano; Tsunami; Weather Fundamentals: Hurricanes and Tornadoes; Bill Nye: Earthquakes, IMAX: Eruption of Mount St. Helen
  - **VHS:** National Geographic: Cyclone; Born of Fire; Earth Science: Earthquakes,
  - **New Path Learning:** Earth’s Surfaces; Plate Tectonics
- Equipment/Supplies:
  - Earthquake models, tectonic plate models

**GRADE 6 PACING GUIDE**

Earth and Space Science Units	1 <sup>st</sup> Trimester	2 <sup>nd</sup> Trimester	3 <sup>rd</sup> Trimester
Unit 1: Earth’s Place in the Universe	X		
Unit 2: Earth’s Systems	X	>	
Unit 3: Earth and Human Activity			X

## GRADE 7 LIFE SCIENCE

In seventh grade students will focus on Life Sciences. The focus will be on the big ideas of structure and processes of organisms, the interaction and dynamics of ecosystems, heredity, and evolution. In structure and processes of organisms the emphasis is on how organisms live, grow and respond to their environment. For ecosystems, the emphasis is on how and why organisms interact with their environment and what effects these interactions have. The emphasis for heredity is how traits are passed from one generation to the next and how that provides for variations among species. With evolution, the emphasis is how organisms can have similarities yet there are so many different species.



## GRADE 7 LIFE SCIENCE

### UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS1-2)
- Develop a model to describe unobservable mechanisms. (MS-LS1-7)

##### **Planning and Carrying Out Investigations**

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5), (MS-LS1-6)

##### **Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3)
- Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)

##### **Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS1-8)

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

**CROSCUTTING CONCEPTS**

**Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8)
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4, MS-LS1-5)

**Scale, Proportion, and Quantity**

- Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)

**Systems and System Models**

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3)

**Energy and Matter**

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7)
- Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)

**Structure and Function**

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-2)

**CONNECTIONS TO NATURE OF SCIENCE**

**Science is a Human Endeavor**

- Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1-3)

**Scientific Knowledge is Based on Empirical Evidence**

- Science knowledge is based upon logical connections between evidence and explanations. (MS-LS1-6)

**Connections to Engineering, Technology and Applications of Science**

**Interdependence of Science, Engineering, and Technology**

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS1-1)

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

**Common Core**

***ELA/Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3)
- RST.6-8.2** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-LS1-5, MS-LS1-6)
- RI.6.8** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3)
- WHST.6-8.1** Write arguments focused on discipline content. (MS-LS1-3)
- WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-5, MS-LS1-6)
- WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1)
- WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-LS1-8)
- WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5, MS-LS1-6)
- SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS1-2)

***Mathematics***

- 6.EE.C.9** Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS1-1, MS-LS1-2, MS-LS1-3)
- 6.SP.A.2** Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS-4, MS-LS1-5)
- 6.SP.B.4** Summarize numerical data sets in relation to their context. (MS-LS1-4, MS-LS1-5)

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

*How do organisms live, grow, and respond to their environment?*

**Core Idea MS-LS1 (CT 7.2):**

MS-LS1.A: Structure and Function

MS-LS1.B: Growth and Development of Organisms

MS-LS1.C: Organization for Matter and Energy Flow in Organisms

MS-LS1.D: Information Processing

MS-PS3.D: Energy in Chemical Processes and Everyday Life

**Objectives: (Performance Expectations)**

**MS-LS1-1:** Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and various types of cells. Distinguish between living and non-living things. **S&EP: Planning and carrying out investigations**

**MS-LS1-2:** Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function (i.e. nucleus, chloroplasts, mitochondria, cell membrane, and cell wall). Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Function of the other organelles is limited to their relationship to the whole cell. Assessment does not include biochemical function of cells or cell parts. **S&EP: Developing and using models**

**MS-LS1-3:** Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. Emphasis is on body organization from cells to tissues and tissues to organs specialized for particular body functions. For example, the interaction of subsystems within a system and the normal functioning of those systems. Body systems include circulatory, excretory, digestive, respiratory, muscular, and nervous. Does not include the mechanisms of one body system independent of others. **S&EP: Engaging in argument from evidence**

**MS-LS1-4:** Use argument based on empirical and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury. **S&EP: Engaging in Argument from Evidence**

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

**MS-LS1-5:** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Does not include genetic mechanisms, gene regulation, or biochemical processes. **S&EP: Constructing Explanations and Designing Solutions**

**MS-LS1-6:** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. Emphasis is on tracing movement of matter and flow of energy. Does not include the biochemical mechanisms of photosynthesis. **S&EP: Constructing Explanations and Designing Solutions**

**MS-LS1-7:** Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released. Does not include details of the chemical reactions for photosynthesis or respiration. **S&EP: Developing and Using Models**

**MS-LS1-8:** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. Does not include mechanisms for the transmission of this information. **S&EP: Obtaining, evaluating, and communicating information**

**Essential Questions**

LS1-A: How do the structures of organisms enable life's functions?

LS1-B: How do organisms grow and develop?

LS1-C: How do organisms obtain and use the matter and energy they need to live and grow?

LS1-D: How do organisms detect, process, and use information about the environment?

PS3-D: How do food and fuel provide energy and why do people say it is produced or used even though energy is conserved?

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS1.A: Structure and Function</b></p> <ul style="list-style-type: none"> <li>• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). Mitosis is a process off cell division that creates new cells.</li> <li>• Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.</li> <li>• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.</li> </ul> <p><b>LS1.B: Growth and Development of Organisms</b></p> <ul style="list-style-type: none"> <li>• Animals engage in characteristic behaviors that increase the odds of reproduction.</li> <li>• Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.</li> <li>• Genetic factors as well as local conditions affect the growth of the adult plant.</li> </ul> <p><b>LS1.C: Organization for Matter and Energy Flow in Organisms</b></p> <ul style="list-style-type: none"> <li>• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• Labs</li> <li>• Online simulations demonstrating body systems at work from: <ul style="list-style-type: none"> <li>○ PBS learning media</li> <li>○ United streaming</li> <li>○ Jason project</li> <li>○ Anatronica</li> <li>○ Purposegames</li> <li>○ Brain pop</li> <li>○ Myscience8</li> <li>○ Virtualbody</li> <li>○ Brainu.org</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> <li>• Lab Reports</li> </ul>

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.</li> </ul> <p><b>LS1.D: Information Processing</b></p> <ul style="list-style-type: none"> <li>• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.</li> </ul> <p><b>PS3.D: Energy in Chemical Processes and Everyday Life</b></p> <ul style="list-style-type: none"> <li>• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.</li> <li>• Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.</li> </ul>		

**GRADE 7 LIFE SCIENCE**  
**UNIT 1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES**  
**RESOURCES**

- Key Concept Words:
  - structure, function, cell, organelle, nucleus, chloroplasts, mitochondria, cell membrane, and cell wall, unicellular, multicellular, tissue, organ, organ system, sensory receptors, stimuli, nerve cells, reproduction, pollination, germination, environmental factors, genetic factors, local factors, photosynthesis, chemical reactions, oxygen, carbon dioxide, molecules, energy, respiration, sensory receptors, stimuli
- Books/magazines:
  - NSTA Science Scope; Scholastic Science
- Videos:
  - **VHS: Bill Nye:** Bones and Muscles; Heart; Cells; Blood and Circulation; **Discovery School:** The Ultimate Guide: Human Body; **Schlessinger:** The Brain and Nervous System; Health and the Human Body; Interrelationship of the Body Systems; Human Machine; Circulatory and Respiratory Systems; Digestive and Excretory Systems; Health and Nutrition; Skeletal and Muscular Systems
- Equipment/Supplies:
  - Human body organ models, e.g. skeleton, torso, heart, joints, lungs, etc., stethoscope, timers, beakers, test tubes, lung capacity spirometer



## **GRADE 7 LIFE SCIENCE**

### **UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to describe phenomena. (MS-LS2-3)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

##### **Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

#### **CROSS CUTTING CONCEPTS**

##### **Patterns**

- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

##### **Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

##### **Energy and Matter**

- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

## GRADE 7 LIFE SCIENCE

### UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

#### Stability and Change

- Small changes in one part of a system might cause large changes in another part. (MS-LS2-5)

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

##### Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

##### Scientific Knowledge is Based on Empirical Evidence

- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

#### **CONNECTIONS TO ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

##### Influence of Science, Engineering, and Technology on Society and the Natural World

- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

#### **COMMON CORE**

##### ***ELA/Literacy***

**RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-2)

**RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)

**RST.6-8.8** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)

**RI.8.8** Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5)

**WHST.6-8.1** Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)

**WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2)

**GRADE 7 LIFE SCIENCE**  
**UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

- WHST.6-8.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2)
- SL.8.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS2-2)
- SL.8.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS2-2)
- SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3)

***Mathematics***

- MP.4** Model with mathematics. (MS-LS2-5)
- 6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5)
- 6.EE.C.9** Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS2-3)
- 6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-LS2-2)

**GRADE 7 LIFE SCIENCE**  
**UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

*How and why do organisms interact with their environment and what are the effects of these interactions?*

**Core Ideas MS-LS2, MS-LS4, & MS-ETS1 (CT 6.2):**

- MS-LS2.A: Interdependent Relationships in Ecosystems
- MS-LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- MS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- MS-LS4.D: Biodiversity and Humans
- MS-ETS1.B: Developing Possible Solutions

**Objectives: (Performance Expectations)**

**MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. **S&EP: Analyzing and Interpreting Data**

**MS-LS2-2:** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial. **S&EP: Constructing Explanations and Designing Solutions**

**MS-LS2-3:** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system. Does not include the use of chemical reactions to describe the processes. **S&EP: Developing and Using Models**

**MS-LS2-4:** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems. **S&EP: Engaging in Argument from Evidence**

**MS-LS2-5:** Evaluate competing design solutions for maintaining biodiversity and ecosystem services. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations. **S&EP: Engaging in Argument From Evidence**

**GRADE 7 LIFE SCIENCE**  
**UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<b>Essential Questions</b>
MS-LS2.A: How do organisms interact with the living and nonliving environments to obtain matter and energy?
MS-LS2.B: How do matter and energy move through an ecosystem?
MS-LS2.C: What happens to ecosystems when the environment changes?
MS-LS4.D: What is biodiversity, how do humans affect it, and how does it affect humans?
MS-ETS1.B: What is the process for developing potential design solutions?

<b>Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)</b>	<b>Instructional Strategies</b>	<b>Evidence of Learning</b>
<p><b>LS2.A: Interdependent Relationships in Ecosystems</b></p> <ul style="list-style-type: none"> <li>Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.</li> <li>In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.</li> <li>Growth of organisms and population increases are limited by access to resources.</li> <li>Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.</li> </ul>	<ul style="list-style-type: none"> <li>Outlining/note taking</li> <li>Identifying text structures</li> <li>Summarizing and or paraphrasing text</li> <li>Annotation</li> <li>Graphic organizers</li> <li>Peer editing</li> <li>Guided writing lessons</li> <li>Use of common rubrics across discipline</li> </ul>	<ul style="list-style-type: none"> <li>Vocabulary check for understanding</li> <li>Content tests and quizzes</li> <li>Document based question responses</li> <li>Participation in class discussions</li> <li>Summaries of various sources</li> <li>Reader responses requiring students to use single and multiple sources to support their claim</li> <li>Projects</li> <li>End of unit assessment</li> </ul>

**GRADE 7 LIFE SCIENCE**  
**UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS2.B: Cycle of Matter and Energy Transfer in Ecosystems</b></p> <ul style="list-style-type: none"> <li>Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.</li> </ul> <p><b>LS2.C: Ecosystem Dynamics, Functioning, and Resilience</b></p> <ul style="list-style-type: none"> <li>Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</li> <li>Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.</li> </ul> <p><b>LS4.D: Biodiversity and Humans</b></p> <ul style="list-style-type: none"> <li>Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.</li> </ul> <p><b>ETS1.B: Developing Possible Solutions</b></p> <ul style="list-style-type: none"> <li>There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.</li> </ul>		

**GRADE 7 LIFE SCIENCE**  
**UNIT 2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**  
**RESOURCES**

- Key concept words:
  - ecosystem, environmental interactions, interdependent, biodiversity, organism, population, biotic factor, abiotic factor, predator, prey, producer, consumer, decomposer, food web, food chain, energy flow, ecosystem services (such as water purification, nutrient recycling, and prevention of soil erosion).
- Books/ magazines:
  - Kids discover, Science World, NSTA Scope
- Videos:
  - **VHS: Discovery School:** Island Ecosystems; Deserts and Grasslands; Temperate Forests; Freshwater; **Biomes of the World in Action:** Marine Ecosystems; **Schlessinger:** Food Chains; Marine and Other Invertebrates; **National Geographic:** Webs of Intrigue; **Bill Nye:** Reptiles and Insects; Simple Organisms in Action: Protists;
  - **DVD:** Bill Nye: Food Webs; Forests; Discovery School: Africa: Namibian Ecosystem; Eyewitness: Rain Forest; Artic and Antarctic
- Equipment/Supplies:
  -

## GRADE 7 LIFE SCIENCE

### UNIT 3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-1, MS-LS3-2)

#### **CROSCUTTING CONCEPTS**

##### **Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

##### **Structure and Function**

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)

#### **COMMON CORE**

##### ***ELA/Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4, MS-LS1-5, MS-LS3-1, MS-LS3-2, MS-LS4-5)
- RST.6-8.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. (MS-LS3-1, MS-LS3-2)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1, MS-LS3-2)
- RI.6.8** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4)
- SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS3-1, MS-LS3-2)

##### ***Mathematics***

- MP.4** Model with mathematics. (MS-LS3-2)
- 6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-LS3-2)



**GRADE 7 LIFE SCIENCE**  
**UNIT 3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS**

*How are traits inherited from one generation to the next in a way that provides variation among a species?*

**Core Ideas MS-LS1, MS-LS3 (CT 8.2):**

- MS-LS1 B: Growth and Development of Organisms
- MS-LS3 A: Inheritance of Traits
- MS-LS3 B: Variation of Traits

**Objectives: (Performance Expectations)**

**MS-LS3-1:** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of organisms. Emphasis is on a conceptual understanding that changes in genetic material may result in making different proteins. Does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations. **S&EP: Developing and using models**

**MS-LS3-2:** Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parents to offspring and resulting genetic variation. **S&EP: Developing and using models**

**Essential Questions**

- MS-LS1 B: How do organisms grow and develop?
- MS-LS3 A: How are the characteristics of one generation related to the previous generation?
- MS-LS3 B: Why do individuals of the same species vary in how they look, function, and behave?

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS1.B: Growth and Development of Organisms</b></p> <ul style="list-style-type: none"> <li>• Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> </ul>

**GRADE 7 LIFE SCIENCE**  
**UNIT 3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS3.A: Inheritance of Traits</b></p> <ul style="list-style-type: none"> <li>• Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.</li> <li>• Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.</li> </ul> <p><b>LS3.B: Variation of Traits</b></p> <ul style="list-style-type: none"> <li>• Meiosis is a process that produces germ cells in sexually reproducing organisms. When two germ cells unite during fertilization, the resulting zygote has two copies of each chromosome, one from each parent. Each parent contributes half of the genes acquired (at random) by the offspring.</li> <li>• Since individuals have two of each chromosome, they hence have two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.</li> <li>• In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.</li> </ul>	<ul style="list-style-type: none"> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• Compare sexual vs asexual reproduction</li> <li>• Interactive notebook</li> <li>• “Nature Puzzler” activities</li> <li>• Demonstrate life cycle of plant by growing Wisconsin Fast Plants and observing parts of a flower using magnification.</li> <li>• Demonstrate environmental and genetic factors that enable plant reproduction and growth.               <ul style="list-style-type: none"> <li>○ Pollination via wind, animals, etc.</li> <li>○ Genetic variation</li> </ul> </li> <li>• Use of chromosome models to demonstrate mitosis/meiosis</li> <li>• Finding Your Genetic Match activity</li> <li>• Virtual Lab – “Mendel’s Pea Plants activities</li> </ul>	<ul style="list-style-type: none"> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> </ul>

**GRADE 7 LIFE SCIENCE**  
**UNIT 3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS**  
**RESOURCES**

- Key Concept Words:
  - organism, sexual reproduction, asexual reproduction, genetic factors, environmental factors, genes, chromosomes, inheritance, proteins, traits, variation, offspring, meiosis, germ cells, zygote, alleles, mutations
- Books/magazines:
  - NSTA *Science Scope*; *Scholastic Science*
- Videos/Promethean Board:
  - **DVD:** Bill Nye: Cells; **Schlessinger:** Genes and Heredity; **Nova:** Cracking the Code; Cell Division: Mitosis and Cytokinesis;
  - **VHS:** Assignment Discovery- The Clone Age
  - **Promethean Board: New Path Learning:** Mitosis; Meiosis; Genetics – The Study of Heredity; Chromosomes, Genes & DNA
- Equipment/Supplies:
  - Bio-Labs DNA models; Mitosis/Meiosis chromosome kit, prepared onion root tip slides for mitosis, hanging DNA model, materials for DNA extraction of peas, human karyotyping kit, Dragon genetics, Punnett square practice kit, Genetics of Bloops kit, Wisconsin Fast plants kits, set-up for growing plants, mitosis simulation kit, DNA game, human genetics simulation game (2), Natural selection kits (2), probability kit, natural selection game, Heredity and the Environment Kit (albino tobacco seeds), Predator vs Prey kit

## GRADE 7 LIFE SCIENCE

### UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze displays of data to identify linear and nonlinear relationships. (MS-LS4-3)
- Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1)

##### **Using Mathematics and Computational Thinking**

Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

- Use mathematical representations to support scientific conclusions and design solutions. (MS-LS4-6)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2)
- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4)

##### **Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS4-5)

#### **CROSSCUTTING CONCEPTS**

##### **Patterns**

- Patterns can be used to identify cause and effect relationships. (MS-LS4-2)
- Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1, MS-LS4-3)

##### **Cause and Effect**

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4, MS-LS4-5, MS-LS4-6)

## GRADE 7 LIFE SCIENCE

### UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### **Scientific Knowledge is Based on Empirical Evidence**

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-LS4-1)

##### **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS4-1, MS-LS4-2)

##### **Science Addresses Questions About the Natural and Material World**

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS4-5)

#### **CONNECTIONS TO ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

##### **Interdependence of Science, Engineering, and Technology**

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS4-5)

#### **COMMON CORE**

##### **ELA/Literacy**

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-1, MS-LS4-2, MS-LS4-3, MS-LS4-4)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1, MS-LS4-3)
- RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-LS4-3, MS-LS4-4)
- WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2, MS-LS4-4)
- WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of theirs while avoiding plagiarism and following a standard format for citation. (MS-LS4-5)
- WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2, MS-LS4-4)

**GRADE 7 LIFE SCIENCE**  
**UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

- SL.8.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS4-2, MS-LS4-4)
- SL.8.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS4-2, MS-LS4-4)

***Mathematics***

- MP.4** Model with mathematics. (MS-LS4-6)
- 6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-LS4-4, MS-LS4-6)
- 6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-LS4-4, MS-LS4-6)
- 6.EE.B.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-LS4-1, MS-LS4-2)
- 7.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-LS4-4, MS-LS4-6)

**GRADE 7 LIFE SCIENCE**  
**UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

*How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?*

**Core Idea MS-LS4 (CT 7.3):**

LS4.A: Evidence of Common Ancestry and Diversity

LS4.B: Natural Selection

LS4.C: Adaptation

**Objectives: (Performance Expectations)**

**MS-LS4-1:** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers. Does not include the names of individual species or geological eras in the fossil record. **S&EP: Analyzing and Interpreting Data**

**MS-LS4-2:** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures. **S&EP: Constructing Explanations and Designing Solutions**

**MS-LS4-3:** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. Comparison is limited to gross appearance of anatomical structures in embryological development. **S&EP: Analyzing and Interpreting Data**

**MS-LS4-4:** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. Emphasis is on using simple probability statements and proportional reasoning to construct explanations. **S&EP: Constructing Explanations and Designing Solutions**

**MS-LS4-5:** Gather and synthesize information about the technologies that have changes the way humans influence the inheritance of desired traits in organisms. Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these discoveries. **S&EP: Obtaining, evaluating, and communicating information**

**GRADE 7 LIFE SCIENCE**  
**UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

**MS-LS4-6:** Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time. Does not include Hardy Weinberg calculations. **S&EP: Using Mathematics and Computational Thinking**

**Essential Questions**

LS4.A: What evidence shows that different species are related?

LS4.B: How does genetic variation among organisms affect survival and reproduction?

LS4.C: How does the environment influence populations of organisms over multiple generations?

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS4.A: Evidence of Common Ancestry and Diversity</b></p> <ul style="list-style-type: none"> <li>• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.</li> <li>• Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.</li> <li>• Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.</li> </ul> <p><b>LS4.B: Natural Selection</b></p> <ul style="list-style-type: none"> <li>• Natural selection leads to the predominance of certain traits in a population, and the suppression of others.</li> <li>• In <i>artificial</i> selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• Simulation activities demonstrating natural selection and adaptation (ex: different beaks in birds)</li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> </ul>



**GRADE 7 LIFE SCIENCE**  
**UNIT 4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>LS4.C: Adaptation</b></p> <ul style="list-style-type: none"> <li>Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.</li> </ul>		

**RESOURCES**

- Key concept words:
  - fossil record, existence, diversity, extinction, anatomical similarities, embryological development, evolution, natural selection, artificial selection, selective breeding, adaptation, survival of the fittest, species, Charles Darwin, uniformitarianism, population, trait
- Books/ magazines:
  - NSTA *Science Scope*; *Scholastic Science*
- Videos/Promethean Board:
  - DVD: Schlessinger:** Geological History; Prehistoric Life; Fossils; Dinosaur
- Equipment/Supplies:
  - Natural selection kit (2), Probability kit, Natural selection game

**GRADE 7 PACING GUIDE**

Life Science Units	1 <sup>st</sup> Trimester	2 <sup>nd</sup> Trimester	3 <sup>rd</sup> Trimester
Unit 1: From Molecules to Organisms: Structures and Processes	X		
Unit 2: Ecosystems: Interactions, Energy, and Dynamics	X	>	
Unit 3: Heredity: Inheritance and Variation of Traits		X	>
Unit 4: Biological Evolution: Unity and Diversity			X

## GRADE 8 PHYSICAL SCIENCE

In eighth grade students will focus on Physical science. The focus will be on the big ideas of matter and its interactions, forces and their interactions, and energy. The emphasis on matter and its interactions will be on explaining the structure, properties, and interactions of matter. For forces and interactions the emphasis is how Newton's laws can explain and predict interactions between objects. The emphasis for energy is how energy can be transferred and conserved.

## **GRADE 8 PHYSICAL SCIENCE**

### **UNIT 1: MATTER AND ITS INTERACTIONS**

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4) (MS-PS1-5)
- Develop a model to describe unobservable mechanisms (MS-PS 1-5)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6)

##### **Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)

#### **CROSSCUTTING CONCEPTS**

##### **Patterns**

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

##### **Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

## **GRADE 8 PHYSICAL SCIENCE**

### **UNIT 1: MATTER AND ITS INTERACTIONS**

#### **Scale, Proportion, and Quantity**

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

#### **Energy and Matter**

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)

#### **Structure and Function**

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3)

### **CONNECTIONS TO NATURE OF SCIENCE**

#### **Scientific Knowledge is Based on Empirical Evidence**

- Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS 1-2)

#### **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

- Laws are regulations or mathematical descriptions of natural phenomena (MS-PS 1-5)

### **CONNECTIONS TO ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

#### **Interdependence of Science, Engineering, and Technology**

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS 1-3)

#### **Influence of Science, Engineering and Technology on Society and Its Natural World**

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by the differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

## GRADE 8 PHYSICAL SCIENCE

### UNIT 1: MATTER AND ITS INTERACTIONS

#### **Common Core**

##### ***ELA/ Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS1-2, MS-PS1-3)
- RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1, MS-PS1-2, MS-PS1-4, MS-PS1-5, MS-PS1-6)
- WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6)
- WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3)

##### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (MS-PS1-1)(MS-PS1-2, MS-PS1-5)
- MP.4** Model with mathematics. (MS-PS1-1, MS-PS1-5)
- 6. RP. A.3** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1, MS-PS1-2, MS-PS1-5)
- 6. SP. B.4** Display numerical data in plots on a number line, including dot plots, histograms, and box plots. (MS-PS1-2)
- 6.SP. B.5** Summarize numerical data sets in relation to their context (MS-PS1-2)
- 6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4)
- 8. EE. A.3** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. (MS-PS1-1)

## GRADE 8 PHYSICAL SCIENCE

### UNIT 1: MATTER AND ITS INTERACTIONS

*How can one explain the structure, properties, and interactions of matter?*

**Core Idea: PS1 Matter and Its Interactions (CT 6.1)**

MS- PS1.A: Structure and Properties of Matter

MS- PS1.B: Chemical Reactions

MS- PS3.A: Definitions of Energy

ETS1.B: Developing Possible Solutions

ETS1.C: Optimizing the Design Solution

**Objectives: (Performance Expectations)**

**MS- PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures. Develop models such as drawings, 3D ball and stick structures or computer models that vary in complexity i.e. ammonia, methanol, sodium chloride, and diamonds. (Does not include valence electrons, bonding energy, or ionic nature of subunits of complex structures. **(SE&P: Developing and using models)**)

**MS-PS1-2:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. e. g. burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. (Analysis is limited to the following properties: density, melting point, boiling point, solubility, flammability, and odor.)

**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. Emphasis on natural resources that undergo a chemical process to form the synthetic material. **(SE&P: Obtaining, evaluating, and communicating information)**

**MS-PS1-4:** Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Emphasis on qualitative molecular-level models of solids, liquids, and gases to show changes in kinetic energy of particles. Models include drawings and diagrams and examples can include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium. **(SE&P: Developing and using models)**

**MS-PS1-5:** Develop and use a model to describe how the total number of atoms does not change in a chemical reaction, and thus mass is conserved. Emphasis on law of conservation of matter and on physical models or drawings. Does not include use of atomic masses, balancing symbolic equations, or intermolecular forces.

**MS-PS1-6:** Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. Emphasis is on design, controlling the transfer of energy to environment, and modification of a device using factors such as type and concentration of substance. Examples could include chemical reactions such as dissolving ammonium chloride or calcium chloride.

**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 1: MATTER AND ITS INTERACTIONS**

**Essential Questions**

PS1.A: How do particles combine to form the variety of matter one observes?

PS1.B: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?

PS3.A: What is energy and how is it transferred and conserved?

EST1.B: What is the potential for developing possible design solutions?

EST1.C: How can various proposed design solutions be compared and improved?

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>PS1.A: Structure and Properties of Matter</b></p> <ul style="list-style-type: none"> <li>• Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.</li> <li>• Pure substances are made from a single type of atom or molecule. Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.</li> <li>• Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.</li> <li>• In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In solids, atoms are closely spaced and may vibrate in position but do not change relative locations.</li> <li>• Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g. crystals).</li> <li>• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (Predictions are qualitative, not quantitative.)</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• Use of models to demonstrate atomic structure (either physical models or paper representations)</li> <li>• Demonstration stations for different properties, e.g. flame tests of various elements</li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> </ul>

**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 1: MATTER AND ITS INTERACTIONS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>PS1.B: Chemical Reactions</b></p> <ul style="list-style-type: none"> <li>Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</li> <li>The total number of each atom is conserved, thus the mass does not change.</li> <li>Some chemical reactions release energy, others store energy.</li> </ul> <p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>The term “heat” as used in everyday language refers both to the thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.</li> <li>The temperature of a system is proportional to the average energy and potential energy per atom or molecule (whichever is appropriate building block for the system’s material.) The details of that relationship depend upon the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system’s total thermal energy. The total thermal energy (sometimes called the total inert energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.</li> </ul> <p><b>ETS1.B Developing Possible Solutions</b></p> <ul style="list-style-type: none"> <li>A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.</li> </ul>	<ul style="list-style-type: none"> <li>Microscopic examination of crystalline structures e. g. sugar, salt</li> <li>Balloon reactions to temperature changes</li> <li>Exo/endothermic demonstrations</li> <li>Students experiment with various substances to determine which provides best solution of a proposed problem</li> </ul>	<ul style="list-style-type: none"> <li>Students propose what could be used in New England winters with freezing or snowy road conditions</li> <li>e. g. claim-evidence-argument</li> </ul>



**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 1: MATTER AND ITS INTERACTIONS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>ETS1.C Optimizing the Design Solution</b></p> <ul style="list-style-type: none"> <li>• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the re-design process – that is, some of the characteristics may be incorporated into the new design.</li> <li>• The process of testing the most promising solutions and modifying what it proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.</li> </ul>		

**RESOURCES**

- Key Concept Words:
  - characteristic properties, mass, weight, volume, density, solubility, saturated solution, boiling point, melting point, homogeneous and heterogeneous mixtures, solution, solvent, solute, particle, atom, element, molecule, metal, nonmetal, metalloid, physical change, chemical change, heat, energy, endothermic, exothermic
- Books/Magazines:
  - NSTA *Science Scope*, 24 Kids Discovery: Matter, 24 Odyssey- The Sweet Chemistry of Chocolate, 24 Odyssey-Elementary, 12 Kids Discovery – Chemistry, Freestyle Express: 23 Mixtures, Compounds & Solutions and 24 Chemical Reactions, Crabtree: 6 Chemical Changes, Mixtures & Solutions, Elements & Compounds, Atoms & Molecules
- Videos/ Promethean Board:
  - **DVD: Bill Nye** – Phases of Matter; Chemical Reactions; Energy; Heat; **Schlessinger Media:** States of Matter; Atoms and Molecules; Chemical Reactions and Electricity
  - **VHS: Assignment Discovery:** The Elements
  - **Promethean Board: New Path Learning:** Properties and States of Matter; Chemical Reactions; Elements & The Periodic Table; Atoms & Chemical Bonding
- Equipment/Supplies:
  - density cubes, density sets, thermometers, beakers, hot plates, Scientific Investigation Kit – What do Scientists Do?, 12 Hand boilers, 6 sets of Ice Melting blocks, 24 Cat’s Eyes lab, 6 Elemento games, 6 The Elements desk posters (PT), 1 Mixture separation challenge, 1 Sci-Neo Chem reactions lab, 6 Insta snows, 6 Atom model packets, model of an atom, 6 sets of Alginate Warm Connection kits

## **GRADE 8 PHYSICAL SCIENCE**

### **UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Asking Questions and Defining Problems**

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. (MS-PS2-3)

##### **Planning and Carrying Out Investigations**

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)
- Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1) Engaging in Argument from Evidence

##### **Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

- Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4)

#### **CROSSCUTTING CONCEPTS**

##### **Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3, MS-PS2-5)

##### **Systems and System Models**

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1, MS-PS2-4),

## **GRADE 8 PHYSICAL SCIENCE**

### **UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

#### **Stability and Change**

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2)

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### **Scientific Knowledge is Based on Empirical Evidence**

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2, MS-PS2-4)

#### **CONNECTIONS TO ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

##### **Influence of Science, Engineering, and Technology on Society and the Natural World**

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)

#### **COMMON CORE**

##### ***ELA/Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS2-1, MS-PS2-3)
- RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1, MS-PS2-2, MS-PS2-5)
- WHST.6-8.1** Write arguments focused on discipline-specific content. (MS-PS2-4)
- WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-1, MS-PS2-2, MS-PS2-5)

##### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (MS-PS2-1, MS-PS2-2, MS-PS2-3)
- 6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1)
- 6.EE.A.2** Write, read, and evaluate expressions in which letters stand for numbers. (MS-PS2-1, MS-PS2-2)

**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

- 7.EE.B.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-PS2-1, MS-PS2-2)
- 7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-PS2-1, MS-PS2-2)

## GRADE 8 PHYSICAL SCIENCE

### UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS

*How can one explain and predict interactions between objects and within systems of objects?*

**Core Idea: PS2 Forces and Interactions (CT 8.1)**

MS-PS2.A: Forces and Motion

MS-PS2.B: Types of Interactions

#### **Objectives: (Performance Expectations)**

**MS-PS2-1:** Apply Newton's third Law to design a solution to a problem involving the motion of two colliding objects.

Examples could include impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

**(SE&P: Constructing Explanations and Designing Solutions)**

**MS-PS2-2:** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. Emphasis on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units. **(SE&P: Planning and Carrying Out Investigations)**

**MS-PS2-3:** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. Examples of devices that include electromagnets, electric motors, or generators. Data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of a motor. **(SE&P: Asking Questions and Defining Problems)**

**MS-PS2-4:** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of the interacting objects. Examples could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of object's within the solar system. **(SE&P: Engaging in Argument from Evidence)**

**MS-PS2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. Examples could be the interactions of magnets, electrically-charged strips of tape, and electrically charged pith balls. Examples of investigations could include first-hand experiences or simulations.

#### **Essential Questions**

PS2.A: How can one predict an object's continued motion, changes in motion, or stability?

PS2.B: What underlying forces explain the variety of interactions observed?

**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>PS2.A: Forces and Motion</b></p> <ul style="list-style-type: none"> <li>• For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).</li> <li>• The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.</li> <li>• All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.</li> </ul> <p><b>PS2.B: Types of Interactions</b></p> <ul style="list-style-type: none"> <li>• Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.</li> <li>• Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.</li> <li>• Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).</li> </ul>	<ul style="list-style-type: none"> <li>• Outlining/note taking</li> <li>• Identifying text structures</li> <li>• Summarizing and or paraphrasing text</li> <li>• Annotation</li> <li>• Graphic organizers</li> <li>• Peer editing</li> <li>• Guided writing lessons</li> <li>• Use of common rubrics across discipline</li> <li>• Use of videos to demonstrate Newton’s Laws of Motion</li> <li>• Demonstration stations for Newton’s three Laws of Motion</li> <li>• Marble ramp designs:</li> <li>• Changing mass of marble, height of ramp, length of ramp, position on ramp, etc.</li> <li>• Newton’s cradle</li> </ul>	<ul style="list-style-type: none"> <li>• Vocabulary check for understanding</li> <li>• Content tests and quizzes</li> <li>• Document based question responses</li> <li>• Participation in class discussions</li> <li>• Summaries of various sources</li> <li>• Reader responses requiring students to use single and multiple sources to support their claim</li> <li>• Projects</li> <li>• End of unit assessment</li> <li>• Students demonstrate Newton’s Laws using a variety of objects i.e. cars, Ward kits to build and demonstrate forces</li> </ul>

**GRADE 8 PHYSICAL SCIENCE**  
**UNIT 2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

**RESOURCES**

- Key Concept Words:
  - motion, point of reference, speed, constant speed, average speed, slope, force, friction, gravity, inertia, mass, acceleration, balanced/unbalanced forces, net force, circular/centripetal motion, Newton's Laws of Motion, air resistance
- Books/Magazines:
  - NSTA *Science Scope*; *Scholastic Science*
- Videos/Promethean Board:
  - **Promethean Board: New Path Learning:** Forces and Motion; Work, Power & Simple Machines
  - **DVD:** Disney: Gravity; The Science of Fun: Thrill Ride; Schlesinger: Simple Machines, Motion and Balance, Forces, Forces in Action
  - **VHS:** Discovery School: Forces and Motion, Roller Coaster Physics; Bill Nye: Powerful Forces: All Pumped Up
- Equipment/Supplies
  - Ward Kits; Vtec plastic cars; Newton cars; various density marbles and ramps; pulleys; spring scales; slotted mass sets, momentum tracks, pendulum, Bell jar/ vacuum set, vacuum tube and vacuum pump, inertia balloon puck set, lever stands for balancing, simple machine kits, inclined plane boards

## GRADE 8 PHYSICAL SCIENCE

### UNIT 3: ENERGY

#### **SCIENCE AND ENGINEERING PRACTICES**

##### **Developing and Using Models**

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to describe unobservable mechanisms. (MS-PS3-2)

##### **Planning and Carrying Out Investigations**

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4)

##### **Analyzing and Interpreting Data**

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)

##### **Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

##### **Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

#### **CROSCUTTING CONCEPTS**

##### **Scale, Proportion, and Quantity**

- Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1, MS-PS3-4)



## GRADE 8 PHYSICAL SCIENCE

### UNIT 3: ENERGY

#### **Systems and System Models**

- Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

#### **Energy and Matter**

- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

#### **CONNECTIONS TO NATURE OF SCIENCE**

##### **Scientific Knowledge is Based on Empirical Evidence**

- Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-4) (MS-PS3-5)

#### **COMMON CORE**

##### ***ELA/Literacy***

- RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS3-1, MSPS3-5)
- RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS3-3, MS-PS3-4)
- RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1)
- WHST.6-8.1** Write arguments focused on discipline content. (MS-PS3-5)
- WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3),(MS-PS3-4)
- SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS3-2)

## GRADE 8 PHYSICAL SCIENCE

### UNIT 3: ENERGY

#### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (MS-PS3-1, MS-PS3-4, MS-PS3-5)
- 6. RP. A.1** Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS3-1, MS-PS3-5)
- 6. RP. A.2** Understand the concept of a unit rate  $a/b$  associated with a ratio  $a:b$  with  $b \neq 0$ , and use rate language in the context of a ratio relationship. (MS-PS3-1)
- 7. RP. A.2** Recognize and represent proportional relationships between quantities. (MS-PS3-1, MS-PS3-5)
- 8. EE. A.1** Know and apply the properties of integer exponents to generate equivalent numerical expressions. (MS-PS3-1)
- 8. EE. A.2** Use square root and cube root symbols to represent solutions to equations of the form  $x^2 = p$  and  $x^3 = p$ , where  $p$  is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that  $\sqrt{2}$  is irrational. (MS-PS3-1)
- 8. F. A.3** Interpret the equation  $y = mx + b$  as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS3-1, MS-PS3-5)
- 6. SP. B.5** Summarize numerical data sets in relation to their context. (MS-PS3-4)

## GRADE 8 PHYSICAL SCIENCE

### UNIT 3: ENERGY

*How is energy transferred and conserved? How do engineers solve problems?*

**Core Idea: PS3 Energy (CT 7.1)**

MS-PS3.A: Definitions of Energy

MS-PS3.B: Conservation of Energy and Energy Transfer

MS-PS3.C: Relationship Between Energy and Forces

ETS 1.A: Defining and Delimiting an Engineering Problem

ETS 1.B: Developing Possible Solutions

**Objectives: (Performance Expectations)**

**MS-PS3-1:** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball. **(S&EP: Analyzing and Interpreting Data)**

**MS-PS3-2:** Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems. **(S&EP: Developing and Using Models)**

**MS-PS3-3:** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. **(S&EP: Constructing Explanations and Designing Solutions)**

**MS-PS3-4:** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. **(S&EP: Planning and Carrying Out Investigations)**

## GRADE 8 PHYSICAL SCIENCE

### UNIT 3: ENERGY

**MS-PS3-5:** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object. Does not include calculations of energy. **(S&EP: Engaging in Argument from Evidence)**

#### Essential Questions

PS3.A: What is energy?

PS3.B: What is meant by conservation of energy and how is energy transferred between objects or systems?

PS3C: How are forces related to energy?

ETS1A: What are the criteria and constraints of a successful solution?

ETS1B: What is the process for developing potential design solutions?

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.</li> <li>A system of objects may also contain stored (potential) energy, depending on their relative positions.</li> <li>Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</li> </ul> <p><b>PS3.B: Conservation of Energy and Energy Transfer</b></p> <ul style="list-style-type: none"> <li>When the motion energy of an object changes, there is inevitably some other change in energy at the same time.</li> <li>The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.</li> </ul>	<ul style="list-style-type: none"> <li>Outlining/note taking</li> <li>Identifying text structures</li> <li>Summarizing and or paraphrasing text</li> <li>Annotation</li> <li>Graphic organizers</li> <li>Peer editing</li> <li>Guided writing lessons</li> <li>Brainstorming ideas for designs</li> <li>Use of common rubrics across discipline</li> </ul>	<ul style="list-style-type: none"> <li>Vocabulary check for understanding</li> <li>Content tests and quizzes</li> <li>Document based question responses</li> <li>Participation in class discussions</li> <li>Summaries of various sources</li> <li>Reader responses requiring students to use single and multiple sources to support their claim</li> <li>Projects</li> <li>End of unit assessment</li> </ul>

**GRADE 8 PHYSICAL SCIENCE  
UNIT 3: ENERGY**

Disciplinary Core Ideas (DCI's) / Grade Level Concepts (CT)	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.</li> </ul> <p><b>PS3.C: Relationship Between Energy and Forces</b></p> <ul style="list-style-type: none"> <li>• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.</li> </ul> <p><b>ETS1.A: Defining and Delimiting an Engineering Problem</b></p> <ul style="list-style-type: none"> <li>• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.</li> </ul> <p><b>ETS1.B: Developing Possible Solutions</b></p> <ul style="list-style-type: none"> <li>• A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Students design a way to test how mass may affect the transfer of energy e. g. different masses of ice melted in same volume of water</li> <li>• Models/demonstration stations such as pendulums, momentum, and roller coasters</li> <li>• Models for testing solutions</li> </ul>	

**GRADE 8 PHYSICAL SCIENCE  
UNIT 3: ENERGY  
RESOURCES**

- Key Word Concepts:
  - Force, friction, gravity, weight, newton, scale, work, joule, effort (input) force, output force, energy, mechanical advantage, energy, potential energy, kinetic energy, energy transformation, conservation of energy, temperature
- Books/Magazines
  - NSTA Science Scope; Scholastic Science
- Videos/Promethean Board:
  - **DVD:** Bill Nye: Heat; Pressure; Wind; The Science of Fun: Thrill Ride
  - **VHS:** Roller Coaster Physics
- Equipment/Supplies
  - Ramps, thermometers, beakers, pulleys, spring scales, masses of different amounts, marbles of different sizes and masses, Newton cars, pendulums, magnets, balloons

**GRADE 8 PACING GUIDE**

Physical Science Units	1 <sup>st</sup> Trimester	2 <sup>nd</sup> Trimester	3 <sup>rd</sup> Trimester
Unit 1: Matter and its Interactions	X		
Unit 2: Motion and Stability: Forces and Interactions		X	
Unit 3: Energy			X

## GRADES 9-12 OVERVIEW

The Waterford Public Schools 9-12 Curriculum is based on the Next Generation Science Standards (NGSS).

The National Research Council's (NRC) *Framework* describes a vision of what it means to be proficient in science. It presents three dimensions that will be combined to form each standard:

### **Dimension 1: Practices**

The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. The NRC emphasizes that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice

### **Dimension 2: Crosscutting Concepts**

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change. These concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world.

### **Dimension 3: Disciplinary Core Ideas**

Unify K–12 science curriculum. Disciplinary ideas are grouped in four domains:

- the physical sciences
- the life sciences
- the earth and space sciences
- engineering, technology and applications of science

Students will be required to take 6 semester courses, equal to 3 credits, to demonstrate knowledge of the NGSS standards.

## GRADES 9-12 OVERVIEW

### **CORE AND COMPONENTS IDEAS IN THE PHYSICAL SCIENCES:**

- **Core Idea PS1: Matter and Its Interactions**
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions
  - PS1.C: Nuclear Processes
  
- **Core Idea PS2: Motion and Stability: Forces and Interactions**
  - PS2.A: Forces and Motion
  - PS2.B: Types of Interactions
  - PS2.C: Stability and Instability in Physical Systems
  
- **Core Idea PS3: Energy**
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer
  - PS3.C: Relationship Between Energy and Forces
  - PS3.D: Energy in Chemical Processes and Everyday Life
  
- **Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer**
  - PS4.A: Wave Properties
  - PS4.B: Electromagnetic Radiation
  - PS4.C: Information Technologies and Instrumentation



## GRADES 9-12 OVERVIEW

### **CORE AND COMPONENT IDEAS IN THE LIFE SCIENCES:**

- **Core Idea LS1: From Molecules to Organisms: Structures and Processes**
  - LS1.A: Structure and Function
  - LS1.B: Growth and Development of Organisms
  - LS1.C: Organization for Matter and Energy Flow in Organisms
  - LS1.D: Information Processing
  
- **Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics**
  - LS2.A: Interdependent Relationships in Ecosystems
  - LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
  - LS2.C: Ecosystem Dynamics, Functioning, and Resilience
  - LS2.D: Social Interactions and Group Behavior
  
- **Core Idea LS3: Heredity: Inheritance and Variation of Traits**
  - LS3.A: Inheritance of Traits
  - LS3.B: Variation of Traits
  
- **Core Idea LS4: Biological Evolution: Unity and Diversity**
  - LS4.A: Evidence of Common Ancestry and Diversity
  - LS4.B: Natural Selection
  - LS4.C: Adaptation
  - LS4.D: Biodiversity and Humans

## GRADES 9-12 OVERVIEW

### **CORE AND COMPONENT IDEAS IN EARTH AND SPACE SCIENCES:**

- **Core Idea ESS1: Earth's Place in the Universe**
  - ESS1.A: The Universe and Its Stars
  - ESS1.B: Earth and the Solar System
  - ESS1.C: The History of Planet Earth
  
- **Core Idea ESS2: Earth's Systems**
  - ESS2.A: Earth Materials and Systems
  - ESS2.B: Plate Tectonics and Large-Scale System Interactions
  - ESS2.C: The Roles of Water in Earth's Surface Processes
  - ESS2.D: Weather and Climate
  - ESS2.E: Biogeology
  
- **Core Idea ESS3: Earth and Human Activity**
  - ESS3.A: Natural Resources
  - ESS3.B: Natural Hazards
  - ESS3.C: Human Impacts on Earth Systems
  - ESS3.D: Global Climate Change

### **CORE AND COMPONENT IDEAS IN ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE**

- **Core Idea ETS1: Engineering Design**
  - ETS1.A: Defining and Delimiting an Engineering Problem
  - ETS1.B: Developing Possible Solutions
  - ETS1.C: Optimizing the Design Solution
  
- **Core Idea ETS2: Links Among Engineering, Technology, Science, and Society**
  - ETS2.A: Interdependence of Science, Engineering, and Technology
  - ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

## GRADES 9-12 OVERVIEW

The NGSS based on the Framework for K–12 Science Education, involves the following conceptual shifts:

1. K-12 Science Education Should Reflect the Interconnected Nature of Science as it is Practiced and Experienced in the Real World.
2. The Next Generation Science Standards are student performance expectations – NOT curriculum. Performance expectations clarify the expectations of what students will know and be able to do by the end of the grade or grade band.
3. The Science Concepts in the NGSS Build Coherently from K–12. The focus on a few Disciplinary Core Ideas is a key aspect of a coherent science education. The Framework identified a basic set of core ideas that are meant to be understood by the time a student completes high school.
4. The NGSS Focus on Deeper Understanding of Content as well as Application of Content. The Framework identified a smaller set of disciplinary Core Ideas that students should know by the time they graduate from high school, and the NGSS are written to focus on the same.
5. Science and Engineering are integrated in the NGSS, from K–12. Engineering and technology provide opportunities for students to deepen their understanding of science by applying their developing scientific knowledge to the solution of practical problems.
6. The NGSS are designed to prepare students for college, career, and citizenship.
7. The NGSS and Common Core State Standards (English Language Arts and Mathematics) are aligned.

## GRADES 9-12 OVERVIEW

Performance Expectations were developed from the component ideas. One to four performance expectations (example: HS-PS1-1) correspond to each component idea.

PHYSICAL SCIENCE	
PS1.A	HS-PS1-1
	HS-PS1-2
	HS-PS1-3
	HS-PS1-4
PS1.B	HS-PS1-5
	HS-PS1-6
	HS-PS1-7
PS1.C	HS-PS1-8
PS2.A	HS-PS2-1
	HS-PS2-2
	HS-PS2-3
PS2.B	HS-PS2-4
	HS-PS2-5
	HS-PS2-6
PS3.A	HS-PS3-1
	HS-PS3-2
	HS-PS3-3
PS3.B	HS-PS3-4
PS3.C	HS-PS3-5
PS4.A	HS-PS4-1
	HS-PS4-2
	HS-PS4-3
	HS-PS4-5
PS4.B	HS-PS4-4
ETS1.A	HS-ETS1-1
ETS1.B	HS-ETS1-3
	HS-ETS1-4
ETS1.C	HS-ETS1-2

LIFE SCIENCE	
LS1.A	HS-LS1-1
	HS-LS1-2
	HS-LS1-3
LS1.B	HS-LS1-4
LS1.C	HS-LS1-5
	HS-LS1-6
	HS-LS1-7
LS2.A	HS-LS2-1
	HS-LS2-2
LS2.B	HS-LS2-3
	HS-LS2-4
	HS-LS2-5
LS2.C	HS-LS2-2
	HS-LS2-6
	HS-LS2-7
LS2.D	HS-LS2-8
LS3.A	HS-LS3-1
LS3.B	HS-LS3-2
	HS-LS3-3
LS4.A	HS-LS4-1
LS4.B	HS-LS4-2
	HS-LS4-3
	HS-LS4-4
LS4.C	HS-LS4-2
	HS-LS4-3
	HS-LS4-4
	HS-LS4-5
LS4.D	HS-LS4-6
	HS-LS4-6
ETS1.A	HS-ETS1-1
ETS1.B	HS-ETS1-3
	HS-ETS1-4
	HS-ETS1-4
ETS1.C	HS-ETS1-2

EARTH AND SPACE SCIENCE	
ESS1.A	HS-ESS1-1
	HS-ESS1-2
	HS-ESS1-3
ESS1.B	HS-ESS1-4
	HS-ESS2-4
ESS1.C	HS-ESS1-5
	HS-ESS1-6
ESS2.A	HS-ESS2-1
	HS-ESS2-2
	HS-ESS2-3
	HS-ESS2-4
ESS2.B	HS-ESS1-5
	HS-ESS2-1
	HS-ESS2-3
ESS2.C	HS-ESS2-5
ESS2.D	HS-ESS2-4
	HS-ESS2-6
	HS-ESS2-7
	HS-ESS3-6
ESS2.E	HS-ESS2-7
ESS3.A	HS-ESS3-1
	HS-ESS3-2
ESS3.B	HS-ESS3-1
ESS3.C	HS-ESS3-3
	HS-ESS3-4
ESS3.D	HS-ESS3-5
	HS-ESS3-6
ETS1.A	HS-ETS1-1
ETS1.B	HS-ETS1-3
	HS-ETS1-4
ETS1.C	HS-ETS1-2

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSES 1 & 2

Earth and Space Science Courses 1 and 2 will have three levels: Standard, Advanced and Honors. Each course will include the Earth and Space Science performance expectations. Students will demonstrate an understanding of the disciplinary core ideas and the science and engineering practices upon successful completion of both courses.

ESS1.A The universe and its stars	Light spectra from stars are used to determine their characteristics, processes, and lifecycles. Solar activity creates the elements through nuclear fusion. The development of technologies has provided the astronomical data that provide the empirical evidence for the Big Bang theory.
ESS1.B Earth and the solar system	Kepler's laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. Changes in Earth's tilt and orbit cause climate changes such as Ice Ages.
ESS1.C The history of planet Earth	The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.
ESS2.A Earth materials and systems	Feedback effects exist within and among Earth's systems.
ESS2.B Plate tectonics and large-scale system interactions	Radioactive decay within Earth's interior contributes to thermal convection in the mantle.
ESS2.C The roles of water in Earth's surface processes	The planet's dynamics are greatly influenced by water's unique chemical and physical properties.
ESS2.D Weather and climate	The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.
ESS2.E Biogeology	The biosphere and Earth's other systems have many interconnections that cause a continual co-evolution of Earth's surface and life on it
ESS3.A Natural resources	Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.
ESS3.B Natural hazards	Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.
ESS3.C Human impacts on Earth systems	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.
ESS3.D Global climate change	Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSES 1 & 2

The following performance expectations will be covered in Earth and Space Science Course 1 and 2.

### *Students who demonstrate understanding can:*

- HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.** Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries. Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.
- HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]
- HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]
- HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]
- HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.** [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]
- HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.** [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]
- HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSES 1 & 2

- HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.** [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]
- HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]
- HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]
- HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]
- HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** [Clarification Statement: **The carbon cycle is a property of the Earth system that arises from interactions among the hydrosphere, atmosphere, geosphere, and biosphere.** Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]
- HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.** [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSES 1 & 2

- HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
- HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]
- HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.\*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]
- HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]
- HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**



## GRADES 9-11 EARTH AND SPACE SCIENCE COURSES 1 & 2

- HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

### CONNECTICUT CONTENT STANDARDS COVERED IN EARTH AND SPACE SCIENCE COURSE 1 AND 2

9.7	Elements on Earth move among reservoirs in the solid earth, oceans, atmosphere and organisms as part of biogeochemical cycles.
9.8	The use of resources by human populations may affect the quality of the environment.
9.9	Some materials can be recycled, but others accumulate in the environment and may affect the balance of the Earth systems.
Earth's Place in the Universe	Earth-based and space-based astronomy reveal the structure, scale and changes in stars, galaxies and the universe over time.
Dynamic Earth Processes	Plate tectonics operating over geologic time has changed the patterns of land, sea and mountains on Earth's surface.
Energy in the Earth System	Energy enters the Earth system primarily as solar radiation and eventually escapes as heat.
	Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.
	Climate is the long-term average of a region's weather and depends on many factors.
Biogeochemical Cycles	Each element on Earth moves among reservoirs which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles.
Structure and Composition of the Atmosphere	Life has changed Earth's atmosphere, and changes in the atmosphere affect conditions for life.

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1

### UNIT 1: SPACE SYSTEMS

#### Essential Questions

*What is the universe, and what goes on in stars?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)</li> <li>▪ The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2) (HS-ESS1-3)</li> <li>▪ The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)</li> <li>▪ Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2) (HS-ESS1-3)</li> <li>▪ Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)</li> <li>▪ Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS-ESS1-1)</li> <li>▪ Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (HS-ESS1-2)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Teach Engineering: Build a Spectrograph</li> <li>▪ Hands On Universe: Solar System Science</li> <li>▪ Teach Engineering: Measuring Light Pollution</li> <li>▪ High Adventure Science: Is there life in outer space?</li> <li>▪ RITES: Measuring What You Can't Touch</li> <li>▪ Concord Consortium: Is There Life in Space?</li> <li>▪ Reading: Science Investigation Takes Many Forms</li> <li>▪ Reading: Our Solar System Formed from Gas and Dust</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cite various forms of astronomical evidence in explaining the Big Bang Theory and the subsequent expansion of the universe</li> <li>▪ Describe the sun in terms of type, approximate age, life cycle, the type of nuclear processes that occur within and the resulting elements that are produced when compared with other stars</li> <li>▪ Describe how the energy from the sun eventually reaches and affects Earth</li> <li>▪ Analyze and predict orbital motions of the planets and satellites (both natural and artificial)</li> </ul>

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1  
UNIT 1: SPACE SYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)</li> <li>▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)</li> <li>▪ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)</li> <li>▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)</li> </ul>		

**RESOURCES**

- Teach Engineering: Build a Spectrograph
  - [https://www.teachengineering.org/googlesearch\\_results.php](https://www.teachengineering.org/googlesearch_results.php)
- Hands On Universe: Solar System Science
  - <http://handsonuniverse.org/usa/activities/>
- Teach Engineering: Measuring Light Pollution
  - [https://www.teachengineering.org/view\\_activity.php?url=collection/nyu\\_/activities/nyu\\_light/nyu\\_light\\_activity1.xml](https://www.teachengineering.org/view_activity.php?url=collection/nyu_/activities/nyu_light/nyu_light_activity1.xml)
- High Adventure Science: Is there life in outer space?
  - <http://has.concord.org/>
- RITES: Measuring What You Can't Touch
  - <http://rites.wikispaces.com/Measuring+What+you+Can't+Touch>
- Concord Consortium: Is There Life in Space?
  - <http://concord.org/stem-resources/there-life-space>
- Reading: Science Investigation Takes Many Forms
- Reading: Our Solar System Formed from Gas and Dust

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1**  
**UNIT 2: EARTH HISTORY**

**Essential Questions**

- How do people reconstruct and date events in Earth’s planetary history?*  
*How do Earth’s major systems interact?*  
*Why do the continents move and what causes earthquakes and volcanoes?*  
*How do living organisms alter Earth’s processes and structures?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)</li> <li>▪ Other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth’s formation and early history. (HS-ESS1-6)</li> <li>▪ Plate tectonics, operating over geologic time, has changed the patterns of land, sea and mountains on Earth’s surface.</li> <li>▪ Evidence from Earth and moon rocks indicates that the solar system was formed from a nebular cloud of dust and gas approximately 4.6 billion years ago.</li> <li>▪ Evidence from geological studies of Earth and other planets suggests that the early Earth was very different from Earth today.</li> <li>▪ Asteroids and meteorites had a significant role in shaping the surface of planets and their moons and in mass extinctions of life on Earth.</li> <li>▪ The development of the Earth over time is intertwined with the development and evolution of the life on the planet.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Paleontological Research Institution: Why Does This Place Look the Way it Does?</li> <li>▪ RITES: Modeling Earthquakes</li> <li>▪ RITES: Plate Tectonics</li> <li>▪ Reading: Scientists Use Indirect Measurements to Examine and Understand Earth’s Interior</li> <li>▪ Reading: Earth’s Rocks and Other Materials Provide a Record of Our History</li> </ul>	<ul style="list-style-type: none"> <li>▪ Reconstruct models of the past positions of plates and create and defend a predictive model for the future movement of plates (HS-ESS2-1)</li> <li>▪ Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. (HS-ESS1-6)</li> <li>▪ Discover and characterize plate boundaries based on data provided by earthquakes, geologic dating, bathymetry and topography (HS-ESS1-5)</li> </ul>

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1**  
**UNIT 2: EARTH HISTORY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is needed to identify patterns. (HS-ESS1-5)</li> <li>▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Reading: Enormous Changes Include Gradual and Catastrophic</li> </ul>	<ul style="list-style-type: none"> <li>▪ Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth (HS-ESS1-5)</li> </ul>

**RESOURCES**

- Paleontological Research Institution: Why Does This Place Look the Way it Does?
  - [http://www.priweb.org/outreach.php?page=teacherprofdev/Teach\\_Guides](http://www.priweb.org/outreach.php?page=teacherprofdev/Teach_Guides)
  - <http://virtualfieldwork.org/Welcome.html>
- RITES: Modeling Earthquakes
  - <http://investigate.ritesproject.net/browse/investigations/726>
- RITES: Plate Tectonics
  - <http://investigate.ritesproject.net/browse/investigations/990>
- Reading: Scientists Use Indirect Measurements to Examine and Understand Earth’s Interior
- Reading: Earth’s Rocks and Other Materials Provide a Record of Our History
- Reading: Enormous Changes Include Gradual and Catastrophic

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1**  
**UNIT 3: HUMAN SUSTAINABILITY**

**Essential Questions**

- How do Earth’s surface processes and human activities affect each other?*
- How do humans depend on Earth’s resources?*
- How do natural hazards affect individuals and societies?*
- How do humans change the planet?*
- How do people model and predict the effects of human activities on Earth’s climate?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS-ESS3-6)</li> <li>▪ Resource availability has guided the development of human society (HS-ESS3-1)</li> <li>▪ All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS-2)</li> <li>▪ Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS-1)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> <li>▪ Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)</li> </ul>	<ul style="list-style-type: none"> <li>▪ National Geographic: Our Human Footprint</li> <li>▪ National Park Service: Devils Postpile National Monument</li> <li>▪ Henryford: Human Impact on Ecosystems</li> <li>▪ High Adventure Science: What are our Energy Choices?</li> <li>▪ Concord Consortium: Engineering Energy Efficiency (Solar House Project)</li> <li>▪ American Geoscience Institute: Where will your next meal come from?</li> <li>▪ Reading: Geology and Human Population</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)</li> <li>▪ Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6)</li> <li>▪ Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)</li> </ul>

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1**  
**UNIT 3: HUMAN SUSTAINABILITY**

<p align="center"><b>Grade Level Expectations</b>  <b>Disciplinary Core Ideas (DCIs)</b>  <i>Students will know:</i></p>	<p align="center"><b>Instructional Strategies</b></p>	<p align="center"><b>Evidence of Learning</b>  <b>S and E Practices</b>  <i>Students will be able to:</i></p>
<ul style="list-style-type: none"> <li>▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</li> <li>▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ESS3-2)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Reading: Natural Resources are Limited</li> <li>▪ Reading: Resources are Distributed Unevenly</li> <li>▪ Reading: Humans Cannot Eliminate Hazards</li> <li>▪ Reading: Scientists Help Society Move Toward Sustainability</li> </ul>	<ul style="list-style-type: none"> <li>▪ Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)</li> <li>▪ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors. (HS-ESS3-2)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)</li> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)</li> <li>▪ Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)</li> <li>▪ Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)</li> <li>▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)</li> <li>▪ Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)</li> </ul>		

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1  
UNIT 3: HUMAN SUSTAINABILITY**

**RESOURCES**

- National Geographic: Our Human Footprint
  - <http://education.nationalgeographic.com/education/activity/mapping-our-human-footprint/?ar a=1>
- National Park Service: Devils Postpile National Monument
  - <http://www.nps.gov/depo/forteachers/classrooms/curriculummaterials.htm>
  - (Chose Climate Science in Focus)
- Henryford: Human Impact on Ecosystems
  - <http://www.thehenryford.org/education/erb/HumanImpactTeacherPacket.pdf>
- High Adventure Science: What are our Energy Choices?
  - <http://resources.has.concord.org/resources/teacher%20guides/EnergyNatGasTG2014.pdf>
- Concord Consortium: Engineering Energy Efficiency (Solar House Project)
  - <http://concord.org/projects/engineering-energy#curriculum>
- American Geoscience Institute: Where will your next meal come from?
  - <http://www.agiweb.org/education/NASA/tr/invest/activities/foodpeopleearth-9-12.pdf>
- Reading: Geology and Human Population
- Reading: Natural Resources are Limited
- Reading: Resources are Distributed Unevenly

**EARTH AND SPACE SCIENCE COURSE 1: FINAL RESOURCES**

- TBD 2016-17

**EARTH AND SPACE SCIENCE COURSE 1: PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Space Systems	X	
Unit 2: Earth History	X	X
Unit 3: Human Sustainability		X



## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1 COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-5, HS-ESS1-6, HS-ESS2-2, HS-ESS2-3, HS-ESS3-1, HS-ESS3-2, HS-ESS3-4, HS-ESS3-5)
- RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2, HS-ESS3-5)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ESS3-5, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5, HS-ESS1-6, HS-ESS3-2, HS-ESS3-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.1** Write arguments focused on discipline-specific content. (HS-ESS1-6, HS-ESS2-7)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2, HS-ESS1-3, HS-ESS1-5, HS-ESS3-1)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
- SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)
- SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1, HS-ESS2-3, HS-ESS2-4)

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 1 COMMON CORE CONNECTIONS

### *Mathematics*

- MP.2** Reason abstractly and quantitatively. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-3, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-2, HS-ESS3-3, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)
- MP.4** Model with mathematics. (HS-ESS1-1, HS-ESS1-4, HS-ESS2-1, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-3, HS-ESS3-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)
- HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-5, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSF-IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6)
- HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSS-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HS-ESS1-6)

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2**  
**UNIT 1: WEATHER AND CLIMATE**

**Essential Questions**

- How and why is Earth constantly changing?*
- What are the predictable patterns caused by Earth’s movement in the solar system?*
- How do Earth’s major systems interact?*
- What regulates weather and climate?*
- How do people model and predict the effects of human activities on Earth’s climate?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS-ESS2-4)</li> <li>▪ The geological record shows that changes to global and interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)</li> <li>▪ The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-4)(HS-ESS2-7)</li> <li>▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)</li> <li>▪ ESS Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict,</li> </ul>	<ul style="list-style-type: none"> <li>▪ High Adventure Science: What is the Future of Earth’s Climate?</li> <li>▪ STORE: Topography, Rainfall and Ecosystems</li> <li>▪ GLOBE Investigations: Atmosphere</li> <li>▪ GLOBE Investigations: Hydrology</li> <li>▪ American Geoscience Institute: Hurricane Katrina</li> <li>▪ Reading: Hazardous Events Can Be Sudden or Gradual</li> <li>▪ Reading: Water is Essential for Life on Earth</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will use heat lamps and spheres to analyze how the angle of insolation impacts temperature at various locations on the sphere and use this model to change orbital angle and distance and relate it to previous climate changes in Earth’s history.</li> <li>▪ Relate geologic record to how the flow of energy input into the Earth have impacted climate.</li> <li>▪ Have students develop a model with soil, water, ice, and measure temperature changes after exposure to a heat lamp. Students will then relate these ideas to the relevant DCI.(HS-ESS3-5)</li> <li>▪ Students will be able to compile and compare data sets on carbon dioxide and temperature concentrations over time and use this date to predict future changes in temperature based on current carbon dioxide</li> </ul>

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2**  
**UNIT 1: WEATHER AND CLIMATE**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>and manage current and future impacts. (HS-ESS3-5)</p> <ul style="list-style-type: none"> <li>▪ Differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.</li> <li>▪ The rotation of Earth influences the circular motions of ocean currents and air.</li> <li>▪ Properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.</li> <li>▪ The interaction of wind patterns, ocean currents, and the distribution of land masses result in a global pattern of latitudinal bands of rain forests and deserts.</li> </ul>		<p>productions.</p> <ul style="list-style-type: none"> <li>▪ Develop a model that relates Hadley cells to regional climates that include deserts, rainforests, and other biomes. (HS-ESS2-4)</li> <li>▪ Map current flow in Northern and Southern hemispheres.</li> <li>▪ Use density boxes to model layering of water due to temperature and salinity. (HS-ESS2-4)</li> <li>▪ Draw a diagram of global wind patterns and relate them to Hadley cells and the rotation of the Earth.</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. (HS-ESS3-5)</li> <li>▪ Some system changes are irreversible. (HS-ESS3-5)</li> </ul>		

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2

### UNIT 1: WEATHER AND CLIMATE

#### RESOURCES

- High Adventure Science: What is the Future of Earth's Climate?
  - [http://has.portal.concord.org/browse/external\\_activities/81](http://has.portal.concord.org/browse/external_activities/81)
- STORE: Topography, Rainfall and Ecosystems
  - <http://store.sri.com/index.html>
- American Geoscience Institute: Hurricane Katrina
  - <http://www.agiweb.org/education/NASA/tr/invest/activities/Hurricane-Katrina.pdf>
- GLOBE Investigations: Atmosphere
  - <http://www.globe.gov/explore-science/globe-investigations>
- GLOBE Investigations: Hydrology
  - <http://www.globe.gov/explore-science/globe-investigations>
- Reading: Hazardous Events Can Be Sudden or Gradual
- Reading: Water is Essential for Life on Earth

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2**  
**UNIT 2: EARTH'S SYSTEMS**

**Essential Questions**

*How do Earth's major systems interact?*

*Why do the continents move, and what causes earthquakes and volcanoes?*

*How do the properties and movements of water shape Earth's surface and affect its systems?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)</li> <li>▪ Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)</li> <li>▪ The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)</li> <li>▪ The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)</li> <li>▪ The many dynamic and delicate feedbacks between the biosphere</li> </ul>	<ul style="list-style-type: none"> <li>▪ Rock and Mineral Identification Labs</li> <li>▪ Smithsonian Institution: Global Volcanism Program (Mapping Volcanoes and Earthquakes)</li> <li>▪ NOVA: Deadly Shadow of Vesuvius</li> <li>▪ NOAA: Understanding Sea Level</li> <li>▪ Water Labs</li> <li>▪ Ocean Tracks: Investigating Marine Migration in a Changing Ocean</li> <li>▪ Reading: Life that Exists Today is a Unique Result of Earth's Systems Interacting</li> </ul>	<ul style="list-style-type: none"> <li>▪ Show examples of how variations in one earth system can have profound influences on another. (HS-ESS2-3), (HS-ESS2-6)</li> <li>▪ Describe the cycling of matter and energy through the earth's interior. (HS-ESS2-3)</li> <li>▪ Describe the cycling of carbon through the earth's spheres. (HS-ESS2-3)</li> <li>▪ Based upon its properties, provide examples of how water has helped to shape the earth's surface and its continued effect on the Earth's materials (HS-ESS2-5)</li> <li>▪ Construct a model of the earth's interior based upon evidence from various technologies and geologic comparisons (HS-ESS2-3). (HS-ESS2-6)</li> <li>▪ Plan and conduct an investigation of the properties of water and its effects on the Earth's materials and surface</li> </ul>

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2**  
**UNIT 2: EARTH'S SYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)</p> <ul style="list-style-type: none"> <li>▪ Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (HS-ESS2-3)</li> </ul>		<p>process to produce data to serve as the basis for evidence, and in the design: and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data, and refine the design accordingly. (HS-ESS2-5)</p> <ul style="list-style-type: none"> <li>▪ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)</li> <li>▪ Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)</li> <li>▪ Science knowledge is based on empirical evidence. (HS-ESS2-3)</li> <li>▪ Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)</li> <li>▪ Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)</li> </ul>
<ul style="list-style-type: none"> <li>▪ The total amount of energy and matter in the carbon cycled is conserved. (HS-ESS2-6)</li> <li>▪ Energy drives the cycling of matter within and between systems on Earth (HS-ESS2-3).</li> <li>▪ The functions and properties of natural and designed objects during chemical weathering and other systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)</li> <li>▪ How to explain the coevolution of the Earth's systems and life on Earth. (HS-ESS2-7)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. One change to the Earth's surface can create feedbacks that cause changes to other Earth systems.(HS-ESS2-2)</li> <li>▪ Science and engineering complement each other in the cycle known as research and development (R&amp;D). Many R&amp;D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)</li> <li>▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)</li> </ul>		

**GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2  
UNIT 2: EARTH'S SYSTEMS**

**RESOURCES**

- Rock and Mineral Identification Labs
  - Video Resources: <http://igp.colorado.edu/>
- Smithsonian Institution: Global Volcanism Program (Mapping Volcanoes and Earthquakes)
  - <http://www.volcano.si.edu/tdpmap/>
- NOVA: Deadly Shadow of Vesuvius
  - [http://www.pbs.org/wgbh/nova/education/activities/2515\\_vesuvius.html](http://www.pbs.org/wgbh/nova/education/activities/2515_vesuvius.html)
- NOAA: Understanding Sea Level
  - [http://oceanservice.noaa.gov/education/yos/lesson/Grades%205-8/sea\\_level\\_teacher\\_guide.pdf](http://oceanservice.noaa.gov/education/yos/lesson/Grades%205-8/sea_level_teacher_guide.pdf)
- Water Labs
- Ocean Tracks: Investigating Marine Migration in a Changing Ocean
  - <http://oceantracks.org/>
- Reading: Life that Exists Today is a Unique Result of Earth's Systems Interacting

**EARTH AND SPACE SCIENCE COURSE 2: FINAL RESOURCES**

- TBD 2015-16

**EARTH AND SPACE SCIENCE COURSE 2: PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Weather and Climate	X	
Unit 2: Earth's Systems		X



## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2 COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-5, HS-ESS1-6, HS-ESS2-2, HS-ESS2-3, HS-ESS3-1, HS-ESS3-2, HS-ESS3-4, HS-ESS3-5)
- RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2, HS-ESS3-5)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ESS3-5, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5, HS-ESS1-6, HS-ESS3-2, HS-ESS3-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.1** Write arguments focused on discipline-specific content. (HS-ESS1-6, HS-ESS2-7)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2, HS-ESS1-3, HS-ESS1-5, HS-ESS3-1)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
- SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)
- SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1, HS-ESS2-3, HS-ESS2-4)

## GRADES 9-11 EARTH AND SPACE SCIENCE COURSE 2 COMMON CORE CONNECTIONS

### *Mathematics*

- MP.2** Reason abstractly and quantitatively. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-3, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-2, HS-ESS3-3, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)
- MP.4** Model with mathematics. (HS-ESS1-1, HS-ESS1-4, HS-ESS2-1, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-3, HS-ESS3-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)
- HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-3, HS-ESS2-4, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4, HS-ESS1-5, HS-ESS1-6, HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4, HS-ESS2-5, HS-ESS2-6, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5, HS-ESS3-6)
- HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSF-IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6)
- HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1, HS-ESS1-2, HS-ESS1-4)
- HSS-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HS-ESS1-6)

## GRADES 9-11 LIFE SCIENCE COURSES 1 & 2

Life Science Courses 1 and 2 will have three levels: Standard, Advanced and Honors. Students will demonstrate an understanding of the disciplinary core ideas and the science and engineering practices upon successful completion of both courses.

LS1.A Structure and function	Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.
LS1.B Growth and development of organisms	Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.
LS1.C Organization for matter and energy flow in organisms	The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy.
LS1.D Information Processing	N/A
LS2.A Interdependent relationships in ecosystems	Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.
LS2.B Cycles of matter and energy transfer in ecosystems	Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in an ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.
LS2.C Ecosystem dynamics, functioning, and resilience	If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.
LS2.D Social interactions and group behavior	Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.
LS3.A Inheritance of traits	DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ
LS3.B Variation of traits	The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.
LS4.A Evidence of common ancestry and diversity	The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.
LS4.B Natural selection	Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.
LS4.C Adaptation	Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.
LS4.D Biodiversity and humans	Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

## GRADES 9-11 LIFE SCIENCE COURSES 1 & 2

The following performance expectations will be covered in Life Science Courses 1 and 2.

### ***Students who demonstrate understanding can:***

- HS-LS1-1.** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]
- HS-LS1-2.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.]
- HS-LS1-3.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.]
- HS-LS1-4.** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]
- HS-LS1-5.** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]
- HS-LS1-6.** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]
- HS-LS1-7.** Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]
- HS-LS2-1.** Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

## GRADES 9-11 LIFE SCIENCE COURSES 1 & 2

- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]
- HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]
- HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]
- HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]
- HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and, extreme changes, such as volcanic eruption or sea level rise.]
- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.\*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
- HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]
- HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
- HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
- HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]

## GRADES 9-11 LIFE SCIENCE COURSES 1 & 2

- HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]
- HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.]
- HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]
- HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]
- HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]
- HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.\*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

## GRADES 9-11 LIFE SCIENCE COURSES 1 & 2

### CONNECTICUT CONTENT STANDARDS COVERED IN LIFE SCIENCE COURSES 1 AND 2

10.1	Fundamental life processes depend on the physical structure and the chemical activities of the cell.
10.2	Microorganisms have an essential role in life processes and cycles on Earth.
10.3	Similarities in the chemical and structural properties of DNA in all living organisms allow the transfer of genes from one organism to another.
10.4	In sexually reproducing organisms, each offspring contains a mix of characteristics inherited from both parents.
10.5	Evolution and biodiversity are the result of genetic changes that occur over time in constantly changing environments.
10.6	Living organisms have the capability of producing populations of unlimited size, but the environment can support only a limited number of individuals from each species.

**GRADES 9-11 LIFE SCIENCE COURSE 1**  
**UNIT 1: STRUCTURE AND FUNCTION**

**Essential Questions**

*How do the structures of organisms enable life's functions?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Multicellular organisms have a hierarchical structural organization which includes the levels of cells, tissues, organs, organ systems and organisms. (HS-LS1-1)</li> <li>▪ There are positive and negative feedback mechanisms in living organisms which help maintain internal conditions within a range even as external conditions change. (HS-LS1-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cell city/analogy</li> <li>▪ Specialized cell poster</li> <li>▪ Cell diagram</li> <li>▪ Cell organelle jigsaw</li> <li>▪ Egg Osmosis Lab</li> <li>▪ Carrot Lab/SBAC-Like Assessment</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop and use a model based on evidence to illustrate the relationships between the functions of different systems and their interactions. (HS-LS1-2)</li> <li>▪ Plan and conduct an investigation individually and collaboratively to provide evidence that feedback mechanisms maintain homeostasis, and refine the design accordingly. (HS-LS1-3)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2)</li> <li>▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-3)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)</li> </ul>		



**GRADES 9-11 LIFE SCIENCE COURSE 1**  
**UNIT 2: INHERITANCE AND VARIATION OF TRAITS**

**Essential Questions**

*How do the structures of organisms enable life's functions?*

*How do organisms grow and develop?*

*How are the characteristics of one generation related to the previous generation?*

*Why do individuals of the same species vary in how they look, function, and behave?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)</li> <li>▪ All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of the cells. (HS-LS1-1) ( HS-LS3-1)</li> <li>▪ In multicellular organisms individual cells grow and then divide via a process called mitosis, with each parent cell passing identical genetic material both daughter cells. Cellular division and differentiation produce and maintain a complex organism. (HS-LS1-4)</li> <li>▪ All cells in an organism have the same genetic content, but the genes expressed by the cell may be regulated in different ways. Some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)</li> <li>▪ Mutations that are caused by errors in DNA replication and environmental factors are sources of genetic variation, which can be inherited. Crossing-over during meiosis can also cause genetic variation. (LS3-2)</li> <li>▪ Environmental factors also affect expression of traits. Thus the variation and distributions of traits observed depends on both genetic and environmental factors. (LS3-2) ( LS3-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Candy DNA Model</li> <li>▪ Protein Synthesis Simulation</li> <li>▪ Mitosis Microscope Lab</li> <li>▪ Meiosis Poster</li> <li>▪ Karyotyping Activity</li> <li>▪ Genetic Disorder Project</li> <li>▪ Baby Flip Lab/Variation of the human face</li> <li>▪ Incomplete and Codominance Jigsaw</li> <li>▪ Flipping Over Colorblindness</li> <li>▪ Pop Bead Cell division</li> <li>▪ Protein Synthesis Magnetic Simulation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Construct an explanation based on valid and reliable evidence (including students' own investigations, models, theories, simulations, and peer review) for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (HS-LS1-1)</li> <li>▪ Ask questions that arise from examining models or a theory to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1)</li> <li>▪ Use a model to illustrate the role of cellular division (meiosis) and differentiation in producing and maintaining complex organisms. (HS-LS1-4)</li> </ul>

**GRADES 9-11 LIFE SCIENCE COURSE 1**  
**UNIT 2: INHERITANCE AND VARIATION OF TRAITS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)</li> <li>▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-LS3-3)</li> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-4)</li> <li>▪ Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3)</li> <li>▪ Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various practice problems using different patterns of inheritance with Punnett Squares</li> <li>▪ Pedigree analysis</li> <li>▪ Hardy-Weinberg equilibrium problems.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to explain the variation and distributions of expressed traits in a population, using digital tools when feasible. (HS-LS3-3)</li> <li>▪ Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2)</li> </ul>

**GRADES 9-11 LIFE SCIENCE COURSE 1**  
**UNIT 3: MATTER AND ENERGY IN ORGANISMS**

**Essential Questions**

*How do organisms obtain and use the matter and energy they need to live and grow?*

*How do matter and energy move through an ecosystem?*

*How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)</li> <li>▪ The hydrocarbon backbones of sugars are used to make other carbon-based molecules that can be assembled into larger molecules, such as proteins or DNA. (HS-LS1-6) (HS-LS1-7)</li> <li>▪ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)</li> <li>▪ Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to cells. (HS-LS1-7)</li> <li>▪ Photosynthesis and cellular respiration (including anaerobic respiration) provide most of the energy for homeostasis and other life processes. (HS-LS2-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Molymod modeling</li> <li>▪ Leaf activity/ search, Why do they change?</li> <li>▪ Supplemental articles about macromolecules</li> <li>▪ Zombie Lab/ food testing</li> <li>▪ Macromolecule Webquest</li> <li>▪ Catalase liver lab</li> <li>▪ Nutrition label analysis</li> <li>▪ Applesauce enzyme lab</li> <li>▪ Enzyme cut-out simulation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy and how cellular respiration is a process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed. (HS-LS1-5), (HS-LS1-6)</li> <li>▪ Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and other large carbon-based molecules in aerobic and anaerobic conditions. (HS-LS1-6), (HS-LS2-3)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2)</li> <li>▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)</li> </ul>		

**GRADES 9-11 LIFE SCIENCE COURSE 1**  
**UNIT 3: MATTER AND ENERGY IN ORGANISMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Arm-linking demo to simulate hydrolysis and dehydration synthesis</li> </ul>	

# GRADES 9-11 LIFE SCIENCE COURSE 1

## RESOURCES

- TBD 2015-16

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Inheritance and Variation of Traits	X	>
Unit 2: Structure and Function		X
Unit 3: Matter and Energy in Organisms		X

### PERFORMANCE TASK OPTIONS

Why do I Crave that Cookie: <ul style="list-style-type: none"> <li>● LS 1-2</li> <li>● LS 1-3</li> <li>● LS 1-6</li> <li>● LS 1-7</li> <li>● extend to LS 2-3</li> </ul>	Unknown Pedigree analysis with explanation (Punnett square and probabilities): <ul style="list-style-type: none"> <li>● LS 3-3</li> </ul>	Specialized Cell Project: <ul style="list-style-type: none"> <li>● LS 1-2</li> </ul>
Carbon cycling Diagram drawing and questions: <ul style="list-style-type: none"> <li>● LS 2-4</li> <li>● LS 2-5</li> </ul>	“Genetics” disorder project: <ul style="list-style-type: none"> <li>● LS 3-1</li> <li>● LS 3-2</li> </ul>	Gatorade vs. Water Argumentative Essay: <ul style="list-style-type: none"> <li>● LS 1-3</li> </ul>

## GRADES 9-11 LIFE SCIENCE COURSE 1 COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6, HS-LS2-7, HS-LS2-8)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1, HS-LS1-6, HS-LS2-1, HS-LS2-2, HS-LS2-3, HS-LS2-6, HS-LS2-8, HS-LS3-1, HS-LS3-2, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6, HS-LS2-7, HS-LS2-8, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6, HS-LS2-7, HS-LS2-8, HS-LS4-5, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-LS3-1, HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.1** Write arguments focused on discipline-specific content. (HS-LS3-2)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1, HS-LS1-6, HS-LS2-1, HS-LS2-2, HS-LS2-3, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4)
- WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6, HS-LS2-3, HS-LS4-6)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3, HS-LS2-7, HS-LS4-6)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS-1-1, HS-LS1-6, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-LS1-3)
- SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-2, HS-LS1-4)

## GRADES 9-11 LIFE SCIENCE COURSE 1 COMMON CORE CONNECTIONS

**SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-LS4-1, HS-LS4-2)

### ***Mathematics***

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-LS1-4)

**HSF-BF.A.1** Write a function that describes a relationship between two quantities. (HS-LS1-4)

**MP.2** Reason abstractly and quantitatively. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-6, HS-LS2-7, HS-LS3-2, HS-LS3-3, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS1-4, HS-LS4-2, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-7)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-7)

**GRADES 9-11 LIFE SCIENCE COURSE 2**  
**UNIT 1: MATTER AND ENERGY IN ORGANISMS**

**Essential Questions**

*How do organisms obtain and use the matter and energy they need to live and grow?*

*How do matter and energy move through an ecosystem?*

*How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. (HS-LS2-4)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-4), (HS-LS2-5)</li> <li>▪ The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis (<i>secondary to HS-LS2-5</i>)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Life in Florida Springs- producer/consumer energy pyramid activity pbs.org/wnet/nature</li> <li>▪ Food web yarn activity</li> <li>▪ Carbon cycle models &amp; discussion of how C cycle can be altered</li> <li>▪ Graphical representation of predator/prey interactions (Rabbit/lynx game)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5)</li> <li>▪ Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (HS-LS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)</li> <li>▪ Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.(HS-LS1-7),(HS-LS2-4)</li> <li>▪ Energy drives the cycling of matter within and between systems. (HS-LS2-3)</li> </ul>		



**GRADES 9-11 LIFE SCIENCE COURSE 2**  
**UNIT 2: INTERDEPENDENCE RELATIONSHIPS IN ECOSYSTEMS**

**Essential Questions**

*How do organisms interact with the living and nonliving environments to obtain matter and energy?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Ecosystems have carrying capacities which result from such factors as the availability of finite living and nonliving resources and from such challenges such as predation, competition, and disease. (HS-LS2-1),(HS-LS2-2)</li> <li>▪ Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. (HS-LS2-2),(HS-LS2-6)</li> <li>▪ Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)</li> <li>▪ Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-6)</li> <li>▪ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). <i>(secondary to HS-LS2-7)</i></li> </ul>	<ul style="list-style-type: none"> <li>▪ NASA: Keeping up with Carbon video (C cycle &amp; climate change; greenhouse effect) <a href="http://www.youtube.com/watch?v=Hrlr3xDhQ0E">http://www.youtube.com/watch?v=Hrlr3xDhQ0E</a></li> <li>▪ Oh deer! Carrying Capacity Simulation</li> <li>▪ Biodiversity Preserves Activity</li> <li>▪ Colony Collapse Disorder and an Analysis of Honeybee Number</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales (HS-LS2-1)</li> <li>▪ Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales(HS-LS2-2)</li> <li>▪ Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem (HS-LS2-6)</li> <li>▪ Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity (HS-LS4-6)</li> <li>▪ Design, evaluate, and refine a solution for reducing the impacts of</li> </ul>

**GRADES 9-11 LIFE SCIENCE COURSE 2**  
**UNIT 2: INTERDEPENDENCE RELATIONSHIPS IN ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. <i>(secondary to HS-LS2-7), (HS-LS4-6)</i></li> <li>▪ When evaluating solutions to mitigate adverse impacts of human activity on biodiversity, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. <i>(secondary to HS-LS2-7),(secondary to HS-LS4-6)</i></li> <li>▪ Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. <i>(secondary to HS-LS4-6)</i></li> </ul>		<p>human activities on the environment and biodiversity (HS-LS2-7)</p>

**GRADES 9-11 LIFE SCIENCE COURSE 2**  
**UNIT 3: NATURAL SELECTION AND EVOLUTION**

**Essential Questions**  
*How do organisms interact in groups so as to benefit individuals?*  
*What evidence shows that different species are related?*  
*How does genetic variation among organisms affect survival and reproduction?*  
*How does the environmental influence populations of organisms over multiple generations?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)</li> <li>▪ There are several lines of evidence of evolution, which include similarities in DNA sequences, amino acid sequences, anatomical structures, and embryology. (HS-LS4-1)</li> <li>▪ Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)</li> <li>▪ The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)</li> <li>▪ Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment’s limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Natural Selection Lab</li> <li>▪ Peppered Moth Simulation</li> <li>▪ Gummy Bear Lab</li> <li>▪ Great Fossil Find</li> <li>▪ Are Humans Evolving? Debate</li> <li>▪ Antibiotic Resistance Simulation</li> <li>▪ Endangered Species Project</li> <li>▪ GMO Debate</li> </ul>	<ul style="list-style-type: none"> <li>▪ Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce. (HS-LS2-8)</li> <li>▪ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking the trait. (HS-LS4-3)</li> <li>▪ Construct an explanation based on evidence for how natural selection leads to adaptations of populations primarily results from four factors: (1) the potential for species to increase in number, (2) the heritable variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and</li> </ul>

**GRADES 9-11 LIFE SCIENCE COURSE 2**  
**UNIT 3: NATURAL SELECTION AND EVOLUTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. (HS-LS4-3),(HS-LS4-4)</li> <li>▪ Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)</li> <li>▪ Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-5)</li> </ul>		<p>reproduce in the environment. (HS-LS4-2),(HS-LS4-4)</p> <ul style="list-style-type: none"> <li>▪ Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (HS-LS4-5)</li> <li>▪ Communicate scientific information in multiple formats (including orally, graphically, textually, and mathematically) that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-LS4-1),(HS-LS4-3)</li> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5)</li> <li>▪ Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-LS4-1),(HS-LS4-4)</li> </ul>		

## GRADES 9-11 LIFE SCIENCE COURSE 2

### RESOURCES

- TBD 2015-16

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Matter and Energy in Organisms	X	
Unit 2: Interdependent Relationships in Ecosystems	X	>
Unit 3: Natural Selection and Evolution		X

### PERFORMANCE TASK OPTIONS

Toothpick/Bean evolution simulation- apply to real world: <ul style="list-style-type: none"> <li>● LS 2-8</li> <li>● LS 4-1</li> <li>● LS 4-2</li> <li>● LS 4-3</li> <li>● LS 4-4</li> <li>● LS 4-5</li> </ul>	Concord Consortium Africans Lion Modeling Population Simulation: <ul style="list-style-type: none"> <li>● LS 2-1</li> </ul>	Biodiversity jigsaw, w/ followup: <ul style="list-style-type: none"> <li>● LS 2-1</li> <li>● LS 4-6</li> </ul>
--	---	--

## GRADES 9-11 LIFE SCIENCE COURSE 2 COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6, HS-LS2-7, HS-LS2-8)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1, HS-LS1-6, HS-LS2-1, HS-LS2-2, HS-LS2-3, HS-LS2-6, HS-LS2-8, HS-LS3-1, HS-LS3-2, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6, HS-LS2-7, HS-LS2-8, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6, HS-LS2-7, HS-LS2-8, HS-LS4-5, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-LS3-1, HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.1** Write arguments focused on discipline-specific content. (HS-LS3-2)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1, HS-LS1-6, HS-LS2-1, HS-LS2-2, HS-LS2-3, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4)
- WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6, HS-LS2-3, HS-LS4-6)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3, HS-LS2-7, HS-LS4-6)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS-1-1, HS-LS1-6, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-LS1-3)
- SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-2, HS-LS1-4)

## GRADES 9-11 LIFE SCIENCE COURSE 2 COMMON CORE CONNECTIONS

**SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-LS4-1, HS-LS4-2)

### ***Mathematics***

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-LS1-4)

**HSF-BF.A.1** Write a function that describes a relationship between two quantities. (HS-LS1-4)

**MP.2** Reason abstractly and quantitatively. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-6, HS-LS2-7, HS-LS3-2, HS-LS3-3, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS1-4, HS-LS4-2, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-7)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-7)

## GRADES 9-11 PHYSICAL SCIENCE COURSES

*CHEMISTRY FOR FUTURE PRESIDENTS / CHEMISTRY I – H / PHYSICS FOR FUTURE PRESIDENTS  
PHYSICS I – H / THE CHEMISTRY & PHYSICS OF FORENSICS*

Physical Science Courses at all levels will include the Physical Science performance expectations. Students will demonstrate an understanding of the disciplinary core ideas and the science and engineering practices upon successful completion of both courses.

PS1.A Structure of matter (includes PS1.C Nuclear processes)	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.
PS1.B Chemical reactions	Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.
PS2.A Forces and motion	Newton’s 2nd law ( $F=ma$ ) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
PS2.C Stability & instability in physical systems	N/A
PS3.A Definitions of energy	The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).
PS3.B Conservation of energy and energy transfer	Systems move toward stable states.
PS3.C Relationship between energy and forces	Fields contain energy that depends on the arrangement of the objects in the field.
PS3.D Energy in chemical processes and everyday life	Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed, it can be converted to less useful forms.
PS4.A Wave properties	The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.
PS4.B Electromagnetic radiation	Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.
PS4.C Information technologies and instrumentation	Large amounts of information can be stored and shipped around as a result of being digitized.



**GRADES 9-11 PHYSICAL SCIENCE COURSES**  
*CHEMISTRY FOR FUTURE PRESIDENTS / CHEMISTRY I – H / PHYSICS FOR FUTURE PRESIDENTS*  
*PHYSICS I – H / THE CHEMISTRY & PHYSICS OF FORENSICS*

The following performance expectations will be covered in the Physical Science courses.

***Students who demonstrate understanding can:***

- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]
- HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]
- HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]
- HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
- HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]
- HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.\*** [Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]
- HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

## GRADES 9-11 PHYSICAL SCIENCE COURSES

### *CHEMISTRY FOR FUTURE PRESIDENTS / CHEMISTRY I – H / PHYSICS FOR FUTURE PRESIDENTS*

### *PHYSICS I – H / THE CHEMISTRY & PHYSICS OF FORENSICS*

- HS-PS1-8.** Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]
- HS-PS2-1.** Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]
- HS-PS2-2.** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]
- HS-PS2-3.** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.\* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]
- HS-PS2-4.** Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]
- HS-PS2-5.** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]
- HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.\* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]
- HS-PS3-1.** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]
- HS-PS3-2.** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

## GRADES 9-11 PHYSICAL SCIENCE COURSES

### *CHEMISTRY FOR FUTURE PRESIDENTS / CHEMISTRY I – H / PHYSICS FOR FUTURE PRESIDENTS*

### *PHYSICS I – H / THE CHEMISTRY & PHYSICS OF FORENSICS*

- HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.\*  
[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]
- HS-PS3-4.** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]
- HS-PS3-5.** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other, including an explanation of how the change in energy of the objects is related to the change in energy of the field.] [Assessment Boundary: Assessment is limited to systems containing two objects.]
- HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]
- HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]
- HS-PS4-3.** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]
- HS-PS4-4.** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

## GRADES 9-11 PHYSICAL SCIENCE COURSES

*CHEMISTRY FOR FUTURE PRESIDENTS / CHEMISTRY I – H / PHYSICS FOR FUTURE PRESIDENTS*

*PHYSICS I – H / THE CHEMISTRY & PHYSICS OF FORENSICS*

- HS-PS4-5.** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.\* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]
- HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

### CONNECTICUT CONTENT STANDARDS COVERED IN LIFE SCIENCE COURSES 1 AND 2

9.1	Energy cannot be created or destroyed; however, energy can be converted from one form to another.
9.2	The electrical force is a universal force that exists between any two charged objects.
9.3	Various sources of energy are used by humans and all have advantages and disadvantages.
9.4	Atoms react with one another to form new molecules.
Atomic and Molecular Structure	The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure.
Chemical Bonds	Biological, chemical and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.
Conservation of Matter and Stoichiometry	The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants.
Reaction Rates	Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules.
Motion and Forces	Newton's laws predict the motion of most objects.
Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
Heat and Thermodynamics	Energy cannot be created or destroyed although, in many processes, energy is transferred to the environment as heat.
Waves	Waves have characteristic properties that do not depend on the type of wave.

## **CHEMISTRY FOR FUTURE PRESIDENTS – A / HONORS CHEMISTRY I – H COURSE DESCRIPTIONS**

### **CHEMISTRY FOR FUTURE PRESIDENTS – A**

CREDIT: ½ credit

This course is an exploratory study of the nature of matter and its reactions that involves problem solving, deductive reasoning and experimentation. Topics included are states of matter; stoichiometry of chemical reactions; electronic structure of atoms and the connection of matter to the periodic chart; energy and equilibrium. This course will explore the relevance of chemistry in everyday life. Students will complete the class with an understanding of how chemical concepts influence decisions made on a daily basis.

### **CHEMISTRY I – H**

CREDIT: ½ credit

This course will be an in depth study of the nature of matter and its reactions. Students will be asked to problem solve and use deductive reasoning and experimentation in real world applications. Topics included are states of matter; stoichiometry of chemical reactions; electronic structure of atoms and the connection of matter to the periodic chart; energy and equilibrium. Scientific experimentation, research, and discussion are integral parts of this course. The honors section places a stronger emphasis on mathematical applications, writing, and independent work than the advanced level class. Students who wish to take AP Science classes and/or pursue science in college should consider taking this course.

**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 1: ENERGY**

**Essential Questions**

*What is energy?*

*What is meant by conservation of energy?*

*How is energy transferred between objects or systems?*

*How do food and fuel provide energy?*

*If energy is conserved, why do people say it is produced or used?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)</li> <li>▪ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)</li> <li>▪ Mathematical expressions allow the concept of conservation of energy to be used to predict and describe chemical reactions gain or loss of energy. (HS-PS3-1)</li> <li>▪ The availability of energy limits what can occur in any chemical reaction. (HS-PS3-1)</li> <li>▪ Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution. (HS-PS3-4)</li> <li>▪ Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)</li> <li>▪ How to design a device that works within specific criteria and constraints to convert chemical energy into thermal energy. (secondary to HS-PS3-3)</li> <li>▪ Temperature is responsible for moving gas molecules faster, and that faster moving molecules will have more kinetic energy. (HS-PS3-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Chemistry is So Cold! Lab</li> <li>▪ Heat Capacity of Unknown Liquid Lab</li> <li>▪ Heat of Neutralization Lab</li> <li>▪ Heat of Neutralization with Hess'</li> <li>▪ Law – HONORS ONLY</li> <li>▪ Making a Heat/Cold Pack Economically</li> <li>▪ Energy of Food Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Plan and conduct an investigation using specific heat concepts individually and collaboratively to produce data which serves as the basis for evidence and refine the design accordingly. (HS-PS3-4)</li> <li>▪ Create a computational model or simulation of <math>q=mc\Delta T</math>. Create a model to explain proportional relationships between, mass, specific heat and temperature. (HS-PS3-1)</li> <li>▪ Design, build and refine device that converts chemical energy into thermal energy a based on prior scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)</li> </ul>

**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 1: ENERGY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Chemical reactions involve energy changes that are proportional to the amount of reactants used. (HS-PS3-1),(HS-PS3-4).</li> </ul>		
<ul style="list-style-type: none"> <li>▪ When investigating or describing a transfer of energy when two components of different temperature are combined within a closed system, the boundaries are defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)</li> <li>▪ Models can be used to predict the change in energy of one component in a system when the change in energy of the other component and energy flows in the system are known, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within the developed device for converting one form of energy into another.(HS-PS3-3)</li> <li>▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)</li> <li>▪ Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)</li> <li>▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)</li> </ul>		

**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 2: STRUCTURES AND PROPERTY OF MATTER**

**Essential Questions**

*How do particles combine to form the variety of matter one observes?*

*What forces hold nuclei together and mediate nuclear processes?*

*What underlying forces explain the variety of interactions observed?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. These electrons are found in electron orbitals, each with a different energy. (HS-PS1-1)</li> <li>▪ The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)</li> <li>▪ The structure and interactions of matter at the macroscopic scale are determined by electrical forces (intramolecular) within and intermolecular forces between atoms. (HS-PS1-3),(secondary to HS-PS2-6)               <ul style="list-style-type: none"> <li>○ The three states of matter may be distinguishable by observable properties at the macroscopic level, and modeled differently at the microscopic level based on molecular motion</li> </ul> </li> <li>▪ Nuclear processes, including fusion, fission, and radioactive decays (alpha, beta, gamma) of unstable nuclei. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)</li> <li>▪ Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-1),(HS-PS1-3),(HS-PS2-6)               <ul style="list-style-type: none"> <li>○ Atoms bond by sharing or transferring electrons</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Lewis Dot Structures/VSEPR – HONORS ONLY</li> <li>▪ Chemical nomenclature based upon periodic</li> <li>▪ Table patterns</li> <li>▪ Introduction of the Mole YouTube Videos</li> <li>▪ Mole Stations</li> <li>▪ Empirical Formulas/Strange Case of Mole</li> <li>▪ Flight Activity</li> <li>▪ Mole and Molarity/Dilutions Notes/WS</li> <li>▪ Kinetic Molecular Theory Simulations</li> <li>▪ Stearic Acid Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop a model to illustrate of the composition of the nucleus of the atom during the processes of fission, fusion, and radioactive decay. (HS-PS1-8)</li> <li>▪ Use the periodic table to predict properties and patterns of atoms based on the patterns of electrons in the outermost energy level of atoms. (HS-PS1-1)</li> <li>▪ Plan and conduct an investigation individually and collaboratively to gather evidence to compare the structure of substances at the macroscopic scale to infer the strength of forces between atoms, and refine the design accordingly. (HS-PS1-3)</li> </ul>



**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 2: STRUCTURES AND PROPERTY OF MATTER**

<b>Grade Level Expectations                      Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning                      S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>○ The properties associated with each bonding style</li> <li>○ Nature of some bonds is related to electronegativity</li> <li>○ Bond polarity is related to molecular polarity</li> </ul> <ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)</li> <li>▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)</li> <li>▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Phase Changing Materials Performance Task</li> </ul>	<ul style="list-style-type: none"> <li>▪ Communicate scientific and technical information gathered from an investigation of intermolecular forces in order to develop and design a process or system in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)</li> </ul>

**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 3: CHEMICAL REACTIONS**

**Essential Questions**

*How do particles combine to form the variety of matter one observes?*

*What forces hold nuclei together and mediate nuclear processes?*

*What underlying forces explain the variety of interactions observed?*

*How do substances combine or change (react) to make new substances?*

*How does one characterize and explain these reactions and make predictions about them?*

*How can the various proposed design solutions be compared and improved?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The periodic table allows for predictions of simple chemical reactions based on valence electrons, trends in the periodic table, and patterns of chemical properties. (HS-PS1-2) (HS-PS1-1.)</li> <li>▪ A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)</li> <li>▪ Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)               <ul style="list-style-type: none"> <li>○ Advanced – qualitatively discuss <i>why</i> endo/exo reactions occur using diagrams and higher/lower energies of reactants vs. products</li> <li>○ Honors-quantitatively calculate the total bond energy changes during a chemical reaction using bond energies from table</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ A Balancing Act Engage/Explore Chemical Reactions</li> <li>▪ Balancing Chemical Equations Notes/WS</li> <li>▪ Law of Conservation of Mass Lab</li> <li>▪ Weight Loss Performance Task</li> <li>▪ Types of Chemical Reactions Explore Lab</li> <li>▪ Stations with Jigsaw Poster Presentation</li> <li>▪ Explain of 6 Types of Reactions with Focus on Driving Force</li> <li>▪ Precipitation, Acid/Base ,Single Replacement Animations with</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop a model to illustrate the release or absorption of energy from a chemical reactions system. (HS-PS1-4)</li> <li>▪ Use mathematical representations of the mole and stoichiometry to support the Law of Conservation of Matter. (HS-PS1-7)</li> <li>▪ Apply scientific principles and evidence to provide an explanation of chemical kinetics and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)</li> <li>▪ Construct and revise an explanation of the Law of Conservation of Matter based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws</li> </ul>

**CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H**  
**UNIT 3: CHEMICAL REACTIONS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ In many reactions, a dynamic and condition-dependent balance between a forward reaction and the reverse reaction determines the numbers of all molecules present. (HS-PS1-6)</li> <li>▪ The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>Worksheets</li> <li>▪ Colorful Precipitates Lab</li> <li>▪ Strawberry Float Engage/Explore Lab</li> <li>▪ Hamburger/Pizza Stoichiometry Engage/Explore</li> <li>▪ Magnesium Oxide Lab</li> <li>▪ 2 grams Lab</li> <li>▪ S'More Explore Stoich Activity</li> <li>▪ Limiting Reactant with Al Foil/CuCl<sub>2</sub> Lab</li> <li>▪ Collision Theory POGIL and pHET simulation</li> <li>▪ All Screwed Up Kinetics Activity</li> <li>▪ Introduction to Equilibrium Beaker/Straw Activity</li> <li>▪ Equilibrium Expressions and Le Chatelier's Principle Lab – HONORS ONLY</li> </ul>	<p>that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)</p> <ul style="list-style-type: none"> <li>▪ Refine the design of a chemical system based on prior scientific knowledge and student-generated data. (HS-PS1-6)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)</li> <li>▪ The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)</li> <li>▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)</li> <li>▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)</li> </ul>		

## CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H RESOURCES

### CHEMISTRY FOR FUTURE PRESIDENTS

- No textbook
- WebAssign- electronic data base of practice problems and assignments
- Chem Matters Magazine- American Chemical Society
- Assorted websites and electronic media

### CHEMISTRY I – H

- Basic Chemistry. Fourth edition. Timberlake and Timberlake. Pearson 2014
- MasteringChemistry®- Pearson Publishing Homework Tutorial and Assessment system

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Energy	X	
Unit 2: Structures and Property of Matter	X	>
Unit 3: Chemical Reactions		X

## CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## CHEMISTRY FOR FUTURE PRESIDENTS – A / CHEMISTRY I – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, (HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **THE CHEMISTRY AND PHYSICS OF FORENSICS – S COURSE DESCRIPTION**

### **THE CHEMISTRY AND PHYSICS OF FORENSICS – S**

CREDIT: ½ credit

This course involves the study of basic chemistry and physics principles using forensics as a backdrop. The course will use a crime investigation scenario as the basis for student learning. Students will engage in laboratory experiments that highlight forensic techniques and demonstrate chemistry and physics topics such as matter and chemical reactions, Newton's laws, and energy. The course focuses on the student's ability to learn chemical and physical concepts through hands-on and group activities.

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S

### UNIT 1: STRUCTURES AND PROPERTY OF MATTER

#### Essential Questions

*How do particles combine to form the variety of matter one observes?*

*What forces hold nuclei together and mediate nuclear processes?*

*What underlying forces explain the variety of interactions observed?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. These electrons are found in electron orbitals, each with a different energy. (HS-PS1-1)</li> <li>▪ The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)</li> <li>▪ The structure and interactions of matter at the macroscopic scale are determined by electrical forces (intramolecular) within and intermolecular forces between atoms. (HS-PS1-3),(secondary to HS-PS2-6)</li> <li>▪ The three states of matter may be distinguishable by observable properties at the macroscopic level, and modeled differently at the microscopic level based on molecular motion</li> <li>▪ Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-1),(HS-PS1-3),(HS-PS2-6)               <ul style="list-style-type: none"> <li>○ Atoms bond by sharing or transferring electrons</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ The Murder of Kristin K-</li> <li>▪ Chemistry, Crime and the Global Society</li> <li>▪ What is physical evidence: Matter (atoms) in all forms)</li> <li>▪ 1st investigation into the murder of Kristin K; The Cooler and the Delivery Truck Evidence</li> <li>▪ Chemical nomenclature based on periodic table patterns;</li> <li>▪ Simulations with various poisoning-Arsenic, lead</li> <li>▪ Physical Evidence collection techniques</li> <li>▪ Case Study: Planted Evidence</li> <li>▪ Case Study: Grave Evidence</li> <li>▪ Argumentative Writing Piece: Types of chewing gum</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use the periodic table to predict properties and patterns of atoms based on the patterns of electrons in the outermost energy level of atoms. (HS-PS1-1)</li> <li>▪ Plan and conduct an investigation individually and collaboratively to gather evidence to compare the structure of substances at the macroscopic scale to infer the strength of forces between atoms, and refine the design accordingly. (HS-PS1-3)</li> <li>▪ Communicate scientific and technical information gathered from an investigation of intermolecular forces in order to develop and design a process or system in multiple formats (including</li> </ul>



**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 1: STRUCTURES AND PROPERTY OF MATTER**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)</li> <li>▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)</li> <li>▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<p>orally, graphically, textually, and mathematically). (HS-PS2-6)</p>

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S

### UNIT 2: CHEMICAL REACTIONS

#### Essential Questions

*How do particles combine to form the variety of matter one observes?*

*What forces hold nuclei together and mediate nuclear processes?*

*What underlying forces explain the variety of interactions observed?*

*How do substances combine or change (react) to make new substances?*

*How does one characterize and explain these reactions and make predictions about them?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The periodic table allows for predictions of simple chemical reactions based on valence electrons, trends in the periodic table, and patterns of chemical properties. (HS-PS1-2) (HS-PS1-1.)</li> <li>▪ A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)</li> <li>▪ In many reactions, a dynamic and condition-dependent balance between a forward reaction and the reverse reaction determines the numbers of all molecules present. (HS-PS1-6)</li> <li>▪ The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ A Balancing Act Engage/Explore Chemical Reactions</li> <li>▪ Law of Conservation of Mass Lab</li> <li>▪ Weight Loss Performance Task-Informative Writing Piece</li> <li>▪ All Screwed Up Kinetics Activity</li> <li>▪ Case Study: Mind Games</li> <li>▪ Kristin K: Drug Lab Evidence</li> <li>▪ Chromatography – FD and C dyes as evidence</li> <li>▪ Spectrophotometry Introduction</li> <li>▪ Longevity of Evidence</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop a model to illustrate the release or absorption of energy from a chemical reactions system. (HS-PS1-4)</li> <li>▪ Use mathematical representations of the mole and stoichiometry to support the Law of Conservation of Matter. (HS-PS1-7)</li> <li>▪ Construct and revise an explanation of the Law of Conservation of Matter based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)</li> <li>▪ The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> </ul>	

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 2: CHEMICAL REACTIONS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)</li> <li>▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)</li> <li>▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Refine the design of a chemical system based on prior scientific knowledge and student-generated data. (HS-PS1-6)</li> </ul>

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S

### UNIT 3: FORCES AND INTERACTIONS

#### Essential Questions

*How can one explain and predict interactions between objects within systems of objects?*

*How can one predict an object's continued motion, changes in motion, or stability?*

*What underlying forces explain the variety of interactions observed?*

*What is design for?*

*What are the criteria and constraints of a successful solution?*

*How can the various proposed design solutions be compared and improved?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)</li> <li>▪ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)</li> <li>▪ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)</li> <li>▪ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)</li> <li>▪ Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5)</li> <li>▪ When forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Active Physics: The Modern Cart and Book Experiment (HS-PS2-1)</li> <li>▪ Active Physics: Force Fields (HS-PS2-4)</li> <li>▪ Active Physics: Newton's Law of Universal Gravitation (HS-PS2-4)</li> <li>▪ ACTIVE Physics: Forces Acceleration and the missing link (HS-PS2-1)</li> <li>▪ The Murder of Kristin K – Weapons Analysis</li> <li>▪ The Murder of Kristin K - Blood spatter analysis and reconstruction of a crime scene</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)</li> <li>▪ Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)</li> </ul>

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 3: FORCES AND INTERACTIONS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The law <math>F = ma</math> is used to solve motion problems that involve constant forces.</li> <li>▪ When one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction applying a force to an object perpendicular to the direction of its motion causes the object to change direction.</li> <li>▪ Newton’s laws are not exact, but provide very good approximations unless an object is small enough that quantum effects become important.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)</li> <li>▪ Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4)</li> <li>▪ Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Systems can be designed to cause a desired effect. (HS-PS2-3)</li> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)</li> </ul>		

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 4: ENERGY**

**Essential Questions**

*What is energy?*

*What is meant by conservation of energy?*

*How is energy transferred between objects or systems?*

*How do food and fuel provide energy?*

*If energy is conserved, why do people say it is produced or used?*

*How are forces related to energy?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)</li> <li>▪ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)</li> <li>▪ Mathematical expressions allow the concept of conservation of energy to be used to predict and describe chemical reactions gain or loss of energy. (HS-PS3-1)</li> <li>▪ The availability of energy limits what can occur in any chemical reaction. (HS-PS3-1)</li> <li>▪ Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution. (HS-PS3-4)</li> <li>▪ Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)</li> <li>▪ How to design a device that works within specific criteria and constraints to convert chemical energy into thermal energy. (<i>secondary to HS-PS3-3</i>)</li> <li>▪ Temperature is responsible for moving gas molecules faster, and that faster moving molecules will have more kinetic energy. (HS-PS3-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Chemistry is So Cold! Lab</li> <li>▪ Heat Capacity of Unknown Liquid Lab</li> <li>▪ Heat of Neutralization Lab with Hess' Law</li> <li>▪ Making a Heat/Cold Pack Economically</li> <li>▪ Energy of Food Lab</li> <li>▪ Chemistry of Fire</li> <li>▪ The murder of Kristin K calorimetry lab</li> <li>▪ Investigation into the type of petroleum used in the "getaway car"</li> <li>▪ Case Study- False and Unreliable</li> <li>▪ Quizzes</li> </ul>	<ul style="list-style-type: none"> <li>▪ Plan and conduct an investigation using specific heat concepts individually and collaboratively to produce data which serves as the basis for evidence and refine the design accordingly. (HS-PS3-4)</li> <li>▪ Create a computational model or simulation of <math>q=mc\Delta T</math>. Create a model to explain proportional relationships between, mass, specific heat and temperature. (HS-PS3-1)</li> <li>▪ Design, build and refine device that converts chemical energy into thermal energy a based on prior scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)</li> </ul>

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 4: ENERGY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Chemical reactions involve energy changes that are proportional to the amount of reactants used. (HS-PS3-1),(HS-PS3-4).</li> <li>▪ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)</li> <li>▪ Energy can be stored in many forms and can be transformed into the energy of motion.</li> <li>▪ Work is the process of making objects move through the application of force.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Define kinetic energy, and identify the variables which effect (and do not effect) the kinetic energy of an object.</li> <li>▪ Define potential energy, identify the variables which effect (and do not effect) the potential energy of an object.</li> <li>▪ Analyze a physical situation and identify whether the total mechanical energy of an object is increasing, decreasing or remaining constant.</li> <li>▪ Apply the principles of energy conservation to a variety of physical situations.</li> </ul>
<ul style="list-style-type: none"> <li>▪ When investigating or describing a transfer of energy when two components of different temperature are combined within a closed system, the boundaries are defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within the developed device for converting one form of energy into another.(HS-PS3-3)</li> <li>▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)</li> </ul>		

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 5: WAVES AND ELECTROMAGNETIC RADIATION**

**Essential Questions**

*What are the characteristic properties and behaviors of waves?*

*What is light?*

*How can one explain the varied effects that involve light?*

*What other forms of electromagnetic radiation are there?*

*How are instruments that transmit and detect waves used to extend human senses?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. <i>(secondary to HS-PS4-5)</i></li> <li>▪ The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)               <ul style="list-style-type: none"> <li>○ Wavelength, frequency and wave speed are related</li> <li>○ In a transverse wave, the medium moves at right angles to the direction in which the wave travels</li> <li>○ The wavelength is the distance between successive identical parts of the wave</li> <li>○ The frequency multiplied by the wavelength equals the speed of the wave</li> </ul> </li> <li>▪ Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5)</li> <li>▪ Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position</li> </ul>	<ul style="list-style-type: none"> <li>▪ Active Physics: Making Waves (HS-PS4-1)</li> <li>▪ Active Physics: Sounds in Strings (HS-PS4-1)</li> <li>▪ Active Physics: Sounds from Vibrating Air (HS-PS4-1)</li> <li>▪ Active Physics: Digital Imaging (HS-PS4-2, HS-PS4-4)</li> <li>▪ Active Physics: Interference of Spectra (HS-PS4-3)</li> <li>▪ Active Physics: The electromagnetic Spectrum (HS-PS4-5)</li> <li>▪ Active Physics: Slinkies and waves (HS-PS4-1)</li> <li>▪ Active Physics: Interference of waves (HS-PS4-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Evaluate questions and take a stance that challenge the premise(s) of digital transmission and storage of information. (HS-PS4-2)</li> <li>▪ Use mathematical representations to support relationships among frequency, wavelength, and speed of waves traveling in various media. (HS-PS4-1)               <ul style="list-style-type: none"> <li>○ Define wave speed and identify the variables which affect wave speed</li> <li>○ Perform straight-forward calculations using the wave equation</li> <li>○ Interpret textual information and diagrams in order to perform mathematical analyses using the wave equation</li> <li>○ Utilize the definition of wave speed to solve simple</li> </ul> </li> </ul>



**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 5: WAVES AND ELECTROMAGNETIC RADIATION**

<p style="text-align: center;"><b>Grade Level Expectations</b>  <b>Disciplinary Core Ideas (DCIs)</b>  <i>Students will know:</i></p>	<p style="text-align: center;"><b>Instructional Strategies</b></p>	<p style="text-align: center;"><b>Evidence of Learning</b>  <b>S and E Practices</b>  <i>Students will be able to:</i></p>
<p>of peaks and troughs of the waves), but they emerge unaffected by each other. (HS-PS4-3)</p> <ul style="list-style-type: none"> <li>▪ Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)</li> <li>▪ When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)</li> <li>▪ Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)</li> <li>▪ Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ‘Interactive Lecture demonstrations: Sound (HS-PS4-1, HS-PS4-3)</li> </ul>	<p>computational problems involving speed, distance, and time</p> <ul style="list-style-type: none"> <li>▪ Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (HS-PS4-3)</li> <li>▪ Describe experiments that demonstrate the particle-like properties of electromagnetic radiation</li> <li>▪ Describe evidence of the wave nature of matter, solve problems relating wavelength to particle momentum</li> <li>▪ Recognize the dual nature of both waves and particles and the impact of the Heisenberg Uncertainty Principle</li> <li>▪ Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter, verifying the data when possible. (HS-PS4-4)</li> <li>▪ Communicate technical information in multiple formats (including orally, graphically, textually, and</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)</li> <li>▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller</li> </ul>		

**THE CHEMISTRY AND PHYSICS OF FORENSICS – S**  
**UNIT 5: WAVES AND ELECTROMAGNETIC RADIATION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>scale mechanisms within the system. (HS-PS4-4)</p> <ul style="list-style-type: none"> <li>▪ Systems can be designed to cause a desired effect. (HS-PS4-5)</li> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows— within and between systems at different scales. (HS-PS4-3)</li> <li>▪ Systems can be designed for greater or lesser stability. (HS-PS4-2)</li> <li>▪ Science and engineering complement each other in the cycle known as research and development (R&amp;D). (HS-PS4-5)</li> <li>▪ Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5)</li> <li>▪ Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)</li> </ul>		<p>mathematically) about how some technological devices, such as a cell phone, use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (HS-PS4-5)</p> <p><b>Connections to Nature of Science</b></p> <ul style="list-style-type: none"> <li>▪ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)</li> </ul>

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S RESOURCES

- Investigating Chemistry. Third Edition; Matthew E. Johl 2013
- Current and past episodes of CSI and Bones
- The American Chemical Society – Chem Matters Magazine
- Equipment-typical science equipment

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Structures and Property of Matter	X	
Unit 2: Chemical Reactions	X	
Unit 3: Forces and Interactions	X	>
Unit 4: Energy		X
Unit 5: Waves and Electromagnetic Radiation		X

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## THE CHEMISTRY AND PHYSICS OF FORENSICS – S COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, S-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H COURSE DESCRIPTIONS

### **PHYSICS FOR FUTURE PRESIDENTS – A**

CREDIT: ½ credit

This course will cover classical and modern physics. It is designed to enable students to appreciate the role of physics in today's society and technology. Emphasis is placed on the fundamental laws of nature on which all science is based. Students will explore the topics of Newton's Laws, wave interactions, the photoelectric effect, and energy.

### **PHYSICS I – H**

CREDIT: ½ credit

In this course the focus is on the big ideas typically included in the first semester of algebra-based, college level physics. Emphasis is placed on the fundamental laws of nature on which all science is based. Students will explore the topics of Newton's Laws, wave interactions, the photoelectric effect, and energy.

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 1: WAVES AND ELECTROMAGNETIC RADIATION**

**Essential Questions**

- How do food and fuel provide energy?*  
*If energy is conserved, why do people say it is produced or used?*  
*What are the characteristic properties and behaviors of waves?*  
*What is light?*  
*How can one explain the varied effects that involve light?*  
*What other forms of electromagnetic radiation are there?*  
*How are instruments that transmit and detect waves used to extend human senses?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. (<i>secondary to HS-PS4-5</i>)</li> <li>▪ The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)               <ul style="list-style-type: none"> <li>○ Wavelength, frequency and wave speed are related</li> <li>○ In a transverse wave, the medium moves at right angles to the direction in which the wave travels</li> <li>○ The wavelength is the distance between successive identical parts of the wave</li> <li>○ The frequency multiplied by the wavelength equals the speed of the wave</li> </ul> </li> <li>▪ Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5)</li> <li>▪ [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase</li> </ul>	<ul style="list-style-type: none"> <li>▪ Active Physics: Making Waves (HS-PS4-1)</li> <li>▪ Active Physics: Sounds in Strings (HS-PS4-1)</li> <li>▪ Active Physics: Sounds from Vibrating Air ( HS-PS4-1)</li> <li>▪ Active Physics: Digital Imaging (HS-PS4-2) (HS-PS4-4)</li> <li>▪ Active Physics: Interference of Spectra (HS-PS4-3)</li> <li>▪ Active Physics: The electromagnetic Spectrum (HS-PS4-5)</li> <li>▪ Active Physics: Slinkies and waves (HS-PS4-1)</li> <li>▪ Active Physics: Interference</li> </ul>	<ul style="list-style-type: none"> <li>▪ Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (HS-PS4-3)               <ul style="list-style-type: none"> <li>○ Describe experiments that demonstrate the particle-like properties of electromagnetic radiation</li> <li>○ Describe evidence of the wave nature of matter, solve problems relating wavelength to particle momentum</li> <li>○ Recognize the dual nature of both waves and particles and the impact of the Heisenberg Uncertainty Principle</li> </ul> </li> </ul>

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 1: WAVES AND ELECTROMAGNETIC RADIATION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>(i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)</p> <ul style="list-style-type: none"> <li>▪ Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)</li> <li>▪ When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)</li> <li>▪ Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)</li> <li>▪ Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)</li> </ul>	<p>of waves (HS-PS4-3)</p> <ul style="list-style-type: none"> <li>▪ Interactive Lecture demonstrations: Sound</li> <li>▪ (HS-PS4-1) (HS-PS4-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter, verifying the data when possible. (HS-PS4-4)</li> <li>▪ Communicate technical information in multiple formats (including orally, graphically, textually, and mathematically) about how some technological devices, such as a cell phone, use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (HS-PS4-5)</li> </ul> <p><b>Connections to Nature of Science</b></p> <ul style="list-style-type: none"> <li>▪ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)</li> <li>▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms</li> </ul>		



**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 1: WAVES AND ELECTROMAGNETIC RADIATION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>within the system. (HS-PS4-4)</p> <ul style="list-style-type: none"> <li>▪ Systems can be designed to cause a desired effect. (HS-PS4-5)</li> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)</li> <li>▪ Systems can be designed for greater or lesser stability. (HS-PS4-2)</li> <li>▪ Science and engineering complement each other in the cycle known as research and development (R&amp;D). (HS-PS4-5)</li> <li>▪ Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5)</li> <li>▪ Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)</li> </ul>		<p>generally modified in light of this new evidence. (HS-PS4-3)</p>

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 2: ENERGY**

<p><b>Essential Questions</b></p> <p><i>How is energy transferred and conserved?</i></p> <p><i>What is energy?</i></p> <p><i>How are forces related to energy?</i></p> <p><i>What is design for?</i></p> <p><i>What are the constraints of a successful solution?</i></p>
---

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)</li> <li>▪ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)</li> <li>▪ These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)</li> <li>▪ When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)</li> <li>▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk</li> </ul>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS-PS3-5)</li> <li>▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)</li> <li>▪ Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)</li> <li>▪ Design, evaluate, and/or refine a solution to a complex real-world</li> </ul>

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 2: ENERGY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (<i>secondary to HS-PS3-3</i>)</p> <ul style="list-style-type: none"> <li>▪ Energy can be stored in many forms and can be transformed into the energy of motion.</li> <li>▪ Work is the process of making objects move through the application of force.</li> </ul>		<p>problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)</p> <ul style="list-style-type: none"> <li>▪ Define kinetic energy, and identify the variables which effect (and do not effect) the kinetic energy of an object.</li> <li>▪ Define potential energy, identify the variables which effect (and do not effect) the potential energy of an object.</li> <li>▪ Analyze a physical situation and identify whether the total mechanical energy of an object is increasing, decreasing or remaining constant.</li> <li>▪ Apply the principles of energy conservation to a variety of physical situations.</li> </ul>
<ul style="list-style-type: none"> <li>▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)</li> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)</li> <li>▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)</li> <li>▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)</li> </ul>		

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 3: FORCES AND INTERACTIONS**

<p><b>Essential Questions</b></p> <p><i>How can one explain and predict interactions between objects within systems of objects?</i></p> <p><i>How can one predict an object's continued motion, changes in motion, or stability?</i></p> <p><i>What underlying forces explain the variety of interactions observed?</i></p> <p><i>What is energy?</i></p> <p><i>What is design for?</i></p> <p><i>What are the criteria and constraints of a successful solution?</i></p> <p><i>How can the various proposed design solutions be compared and improved?</i></p>
---

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)</li> <li>▪ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)</li> <li>▪ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2, HS-PS2-3)</li> <li>▪ Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)</li> <li>▪ Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4, HS-PS2-5)</li> <li>▪ “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (<i>secondary to HS-PS2-5</i>)</li> <li>▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into</li> </ul>	<ul style="list-style-type: none"> <li>▪ Active Physics: The traditional Cart and Book Experiment (HS-PS2-1)</li> <li>▪ Active Physics: The Modern Cart and Book Experiment (HS-PS2-1)</li> <li>▪ Interactive Lecture Demonstration: Newton’s 1st and 2nd Law (HS-PS2-1)</li> <li>▪ Interactive Lecture demonstration: Momentum: (HS-PS2-2) (HS-PS2-3)</li> <li>▪ Active Physics: Force Fields (HS-PS2-4)</li> <li>▪ Active Physics: Newton’s Law of Universal Gravitation (HS-PS2-4)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)</li> <li>▪ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)</li> <li>▪ Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)</li> </ul>

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 3: FORCES AND INTERACTIONS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (<i>secondary to HS-PS2-3</i>)</p> <ul style="list-style-type: none"> <li>▪ Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (<i>secondary to HS-PS2-3</i>)</li> <li>▪ when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest.</li> <li>▪ the law <math>F = ma</math> is used to solve motion problems that involve constant forces.</li> <li>▪ when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction applying a force to an object perpendicular to the direction of its motion causes the object to change direction.</li> <li>▪ Newton’s laws are not exact, but provide very good approximations unless an object is small enough that quantum effects become important.</li> <li>▪ gravitation is a universal force that each mass exerts on any other mass.</li> <li>▪ The principles of conservation of momentum and energy can be used to solve problems involving elastic and inelastic collisions.</li> </ul>	<ul style="list-style-type: none"> <li>▪ ACTIVE Physics: Forces Acceleration and the missing link (HS-PS2-1)</li> <li>▪ Interactive Lecture Demonstrations: Newtons Third Law. (HS-PS2-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)</li> <li>▪ Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4)</li> <li>▪ Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)</li> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5)</li> </ul>		

**PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H**  
**UNIT 3: FORCES AND INTERACTIONS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Systems can be designed to cause a desired effect. (HS-PS2-3)</li> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)</li> </ul>		

**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Waves and Electromagnetic Radiation	X	
Unit 2: Energy	X	>
Unit 3: Forces and Interactions		X

## PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## PHYSICS FOR FUTURE PRESIDENTS – A / PHYSICS I – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)



## **CHEMISTRY II – H COURSE DESCRIPTION**

### **CHEMISTRY II – H**

CREDIT: ½ credit

This course will be a continuation of Chemistry I Honors. All students wanting to take the honors level, will be encouraged to take both semesters of chemistry. This course will be an in depth study of thermodynamics, gas laws, solution chemistry and organic chemistry. Students will be asked to problem solve and use deductive reasoning and experimentation in real world applications. Scientific experimentation, research, and discussion are integral parts of this course. The honors section places a strong emphasis on mathematical applications, writing, and independent work. Students, who wish to take AP Chemistry, must complete this course prior.

## CHEMISTRY II – H

### UNIT 1: THERMODYNAMICS

#### Essential Questions

*What is energy?*

*What is meant by conservation of energy?*

*How is energy transferred between objects or systems?*

*How do food and fuel provide energy?*

*If energy is conserved, why do people say it is produced or used?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.</li> <li>▪ Entropy is a measure of the dispersal of matter and energy.</li> <li>▪ Some physical or chemical processes involve <i>both</i> a decrease in the internal energy of the components under consideration <i>and</i> an increase in the entropy of those components. These processes are necessarily “thermodynamically favored”.</li> <li>▪ If a chemical or physical process is not driven by <i>both</i> entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.</li> <li>▪ A thermodynamically favored process may not occur due to kinetic constraints.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Rubber Band Thermodynamics Activity</li> <li>▪ Using <math>\Delta G</math> to Calculate <math>K_{sp}</math> of Borax</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use representations and models to predict the sign and relative magnitude of entropy change associated with chemical or physical processes</li> <li>▪ Predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both <math>\Delta H</math> and <math>\Delta S</math>, and calculation or estimation of <math>\Delta G</math> when needed</li> <li>▪ Determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy</li> <li>▪ Explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical</li> </ul>

**CHEMISTRY II – H**  
**UNIT 2: GASES**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties</li> <li>▪ A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently</li> <li>▪ Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations.</li> <li>▪ The temperature of a system is a direct measure of the average kinetic energy associated with random motion.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Gas Law Demonstrations (Marshmallow Man, Hot Air Balloon, Balloon in a Vacuum)</li> <li>▪ Gas Law Jigsaw Poster Presentation using pHet Simulation</li> <li>▪ Air bag performance task</li> <li>▪ Calculating Molar Mass of Vapor Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use Kinetic Molecular Theory and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors</li> <li>▪ Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample</li> <li>▪ Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases</li> <li>▪ Relate volumes or pressures of gases to identify stoichiometry relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion</li> <li>▪ Relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy</li> </ul>

**CHEMISTRY II – H**  
**UNIT 3: SOLUTION CHEMISTRY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Solutions are homogeneous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.</li> <li>▪ The formation of a solution may be an exothermic or endothermic process, depending on the relative strengths of intermolecular/interparticle interactions before and after the dissolution process.</li> <li>▪ Solubility of solutes is affected by many factors such as surface area, temperature, and concentration.</li> <li>▪ Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory</li> <li>▪ Solutions have different properties than pure liquids due to the presence of solutes</li> <li>▪ Chemical equilibrium plays an important role in solubility and acid-base chemistry</li> <li>▪ A chemical change may be represented by a molecular, ionic, or net ionic equation</li> <li>▪ In a neutralization reaction, protons are transferred from an acid to a base</li> <li>▪ In oxidation-reduction reactions, there is a net transfer of electrons. The species that loses electrons is oxidized and the species that gains electrons is reduced.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Chromatography lab</li> <li>▪ Freezing Point Depression and Ice Cream Lab</li> <li>▪ The Amazing Net Ionic Race Activity</li> <li>▪ Standardization of NaOH Lab</li> <li>▪ Redox Titration of <math>\text{KMnO}_4</math> Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Explain how solutes can be separated by chromatography based on intermolecular interactions</li> <li>▪ Draw and/or interpret representations of solutions that show the interactions between the solute and solvent</li> <li>▪ Create or interpret representations that link the concept of molarity with particle views of solutions</li> <li>▪ Design and /or interpret the results of a chromatography experiment in terms of relative strength of interactions among and between the components</li> <li>▪ Explain the relationship between equilibrium and solubility</li> <li>▪ Interpret a solubility curve</li> <li>▪ Describe and give everyday examples of colligative properties</li> <li>▪ Translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances</li> <li>▪ Relate measured masses of substances or volumes of solutions to identify stoichiometry relationships for a reaction,</li> </ul>

**CHEMISTRY II – H**  
**UNIT 3: SOLUTION CHEMISTRY**

<b>Grade Level Expectations</b> <b>Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning</b> <b>S and E Practices</b> <i>Students will be able to:</i>
		including situations involving limiting reactants and situations in which the reaction has not gone to completion <ul style="list-style-type: none"> <li>▪ Identify compounds as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify identification</li> <li>▪ Design and/or interpret the results of an experiment involving a redox titration</li> </ul>

**CHEMISTRY II – H**  
**UNIT 4: ORGANIC CHEMISTRY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Organic chemicals have carbon backbones and that the names of these chemicals are often a result of their backbone structure</li> <li>▪ Non-covalent and intermolecular interactions play important roles in many biological and polymer systems</li> <li>▪ Isomers have same chemical formulas but may differ in structure, geometry, position, or function</li> </ul>	<ul style="list-style-type: none"> <li>▪ Modeling Organic Compounds with Moly-Mods Activity</li> <li>▪ IUPAC Organic Nomenclature POGIL</li> <li>▪ Synthesis of an Ester Lab</li> <li>▪ Synthesis and Purification of Caffeine Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Identify structural features and functional groups in an organic molecule</li> <li>▪ Name a hydrocarbon based on backbone and branches using IUPAC system</li> <li>▪ Identify isomers</li> <li>▪ Identify polymers</li> </ul>

**RESOURCES**

- *Basic Chemistry*. Fourth edition. Timberlake and Timberlake. Pearson 2014
- *MasteringChemistry*®- Pearson Publishing Homework Tutorial and Assessment system

**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Thermodynamics	X	
Unit 2: Gases	X	
Unit 3: Solution Chemistry	X	>
Unit 4: Organic Chemistry		X

## CHEMISTRY II – H COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## CHEMISTRY II – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)



## AP PHYSICS II – H COURSE DESCRIPTION

### AP PHYSICS II – H

CREDIT:  $\frac{1}{2}$  credit

In this course the focus is on the big ideas typically included in the first semester of algebra-based, college level physics and is a continuation of Physics 1 Honors. Students will cultivate a deeper understanding of physics as they explore Kinematics, dynamics, circular motion, simple harmonic motion, conservation of momentum/angular momentum, torque, electrostatics, and DC circuits. Students enrolled in this course will have the opportunity to take the Physics 1 AP exam in May.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

#### **BIG IDEA 1: OBJECTS AND SYSTEMS HAVE PROPERTIES SUCH AS MASS AND CHARGE. SYSTEMS MAY HAVE INTERNAL STRUCTURE.**

**Enduring Understanding 1.A:** The internal structure of a system determines many properties of the system.

Essential Knowledge 1.A.1: A system is an object or a collection of objects. Objects are treated as having no internal structure.

Essential Knowledge 1.A.5: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.

**Enduring Understanding 1.B:** Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.

Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.

Essential Knowledge 1.B.2: There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge.

Essential Knowledge 1.B.3: The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.

**Enduring Understanding 1.C:** Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

Essential Knowledge 1.C.1: Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems.

Essential Knowledge 1.C.2: Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.

Essential Knowledge 1.C.3: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

**Enduring Understanding 1.E:** Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.

Essential Knowledge 1.E.2: Matter has a property called resistivity.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

#### **BIG IDEA 2: FIELDS EXISTING IN SPACE CAN BE USED TO EXPLAIN INTERACTIONS.**

**Enduring Understanding 2.A:** A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long–range forces) as well as a variety of other physical phenomena.

Essential Knowledge 2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.

**Enduring Understanding 2.B:** A gravitational field is caused by an object with mass.

Essential Knowledge 2.B.1: A gravitational field  $g$  at the location of an object with mass  $m$  causes a gravitational force of magnitude  $mg$  to be exerted on the object in the direction of the field.

Essential Knowledge 2.B.2: The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object.

#### **BIG IDEA 3: THE INTERACTIONS OF AN OBJECT WITH OTHER OBJECTS CAN BE DESCRIBED BY FORCES.**

**Enduring Understanding 3.A:** All forces share certain common characteristics when considered by observers in inertial reference frames.

Essential Knowledge 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.

Essential Knowledge 3.A.2: Forces are described by vectors.

Essential Knowledge 3.A.3: A force exerted on an object is always due to the interaction of that object with another object.

Essential Knowledge 3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.

**Enduring Understanding 3.B:** Classically, the acceleration of an object interacting with other objects can be predicted by using  $\mathbf{p} = \mathbf{p} + \mathbf{F} \Delta t$  and  $\mathbf{a} = \mathbf{F} / m$ .

Essential Knowledge 3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.

Essential Knowledge 3.B.2: Free–body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.

Essential Knowledge 3.B.3: Restoring forces can result in oscillatory motion. When a linear restoring force is exerted on an object displaced from an equilibrium position, the object will undergo a special type of motion called simple harmonic motion. Examples should include gravitational force exerted by the Earth on a simple pendulum, mass–spring oscillator.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

**Enduring Understanding 3.C:** At the macroscopic level, forces can be categorized as either long–range (action– at–a–distance) forces or contact forces.

Essential Knowledge 3.C.1: Gravitational force describes the interaction of one object that has mass with another object that has mass.

Essential Knowledge 3.C.2: Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.

Essential Knowledge 3.C.4: Contact forces result from the interaction of one object touching another object, and they arise from interatomic electric forces. These forces include tension, friction, normal, spring (Physics 1), and buoyant (Physics 2).

**Enduring Understanding 3.D:** A force exerted on an object can change the momentum of the object.

Essential Knowledge 3.D.1: The change in momentum of an object is a vector in the direction of the net force exerted on the object.

Essential Knowledge 3.D.2: The change in momentum of an object occurs over a time interval.

**Enduring Understanding 3.E:** A force exerted on an object can change the kinetic energy of the object.

Essential Knowledge 3.E.1: The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted.

**Enduring Understanding 3.F:** A force exerted on an object can cause a torque on that object.

Essential Knowledge 3.F.1: Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis.

Essential Knowledge 3.F.2: The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.

Essential Knowledge 3.F.3: A torque exerted on an object can change the angular momentum of an object.

**Enduring Understanding 3.G:** Certain types of forces are considered fundamental.

Essential Knowledge 3.G.1: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.

#### **BIG IDEA 4: INTERACTIONS BETWEEN SYSTEMS CAN RESULT IN CHANGES IN THOSE SYSTEMS.**

**Enduring Understanding 4.A:** The acceleration of the center of mass of a system is related to the net force exerted on the system, where  $\rho \rho a F m = \Sigma$ .

Essential Knowledge 4.A.1: The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

Essential Knowledge 4.A.2: The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

Essential Knowledge 4.A.3: Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center-of-mass velocity of that system.

**Enduring Understanding 4.B: Interactions with other objects or systems can change the total linear momentum of a system.**

Essential Knowledge 4.B.1: The change in linear momentum for a constant-mass system is the product of the mass of the system and the change in velocity of the center of mass.

Essential Knowledge 4.B.2: The change in linear momentum of the system is given by the product of the average force on that system and the time interval during which the force is exerted.

**Enduring Understanding 4.C: Interactions with other objects or systems can change the total energy of a system.**

Essential Knowledge 4.C.1: The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy.

Essential Knowledge 4.C.2: Mechanical energy (the sum of kinetic and potential energy) is transferred into or out of a system when an external force is exerted on a system such that a component of the force is parallel to its displacement. The process through which the energy is transferred is called work.

**Enduring Understanding 4.D: A net torque exerted on a system by other objects or systems will change the angular momentum of the system.**

Essential Knowledge 4.D.1: Torque, angular velocity, angular acceleration, and angular momentum are vectors and can be characterized as positive or negative depending upon whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis.

Essential Knowledge 4.D.2: The angular momentum of a system may change due to interactions with other objects or systems.

Essential Knowledge 4.D.3: The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.

#### **BIG IDEA 5: CHANGES THAT OCCUR AS A RESULT OF INTERACTIONS ARE CONSTRAINED BY CONSERVATION LAWS.**

**Enduring Understanding 5.A: Certain quantities are conserved, in the sense that the changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems.**

Essential Knowledge 5.A.1: A system is an object or a collection of objects. The objects are treated as having no internal structure.

Essential Knowledge 5.A.2: For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

Essential Knowledge 5.A.3: An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system.

Essential Knowledge 5.A.4: The boundary between a system and its environment is a decision made by the person considering the situation in order to simplify or otherwise assist in analysis.

#### **Enduring Understanding 5.B: The energy of a system is conserved.**

Essential Knowledge 5.B.1: Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects.

Essential Knowledge 5.B.2: A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy. [Physics 1: includes mass–spring oscillators and simple pendulums. Physics 2: charged object in electric fields and examining changes in internal energy with changes in configuration.]

Essential Knowledge 5.B.3: A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces.

Essential Knowledge 5.B.4: The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.

Essential Knowledge 5.B.5: Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system. [A piston filled with gas getting compressed or expanded is treated in Physics 2 as a part of thermodynamics.]

Essential Knowledge 5.B.9: Kirchhoff's loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff's laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors.

#### **Enduring Understanding 5.C: The electric charge of a system is conserved.**

Essential Knowledge 5.C.3: Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady–state situations. For circuits with capacitors, situations should be limited to open circuit, just after circuit is closed, and a long time after the circuit is closed.]

#### **Enduring Understanding 5.D: The linear momentum of a system is conserved.**

Essential Knowledge 5.D.1: In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.

Essential Knowledge 5.D.2: In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

Essential Knowledge 5.D.3: The velocity of the center of mass of the system cannot be changed by an interaction within the system. [Physics 1: includes no calculations of centers of mass; the equation is not provided until Physics 2. However, without doing calculations, Physics 1 students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or two spheres of equal mass.]

**Enduring Understanding 5.E: The angular momentum of a system is conserved.**

Essential Knowledge 5.E.1: If the net external torque exerted on the system is zero, the angular momentum of the system does not change.

Essential Knowledge 5.E.2: The angular momentum of a system is determined by the locations and velocities of the objects that make up the system. The rotational inertia of an object or system depends upon the distribution of mass within the object or system. Changes in the radius of a system or in the distribution of mass within the system result in changes in the system's rotational inertia, and hence in its angular velocity and linear speed for a given angular momentum. Examples should include elliptical orbits in an Earth-satellite system. Mathematical expressions for the moments of inertia will be provided where needed. Students will not be expected to know the parallel axis theorem.

#### **BIG IDEA 6: WAVES CAN TRANSFER ENERGY AND MOMENTUM FROM ONE LOCATION TO ANOTHER WITHOUT THE PERMANENT TRANSFER OF MASS AND SERVE AS A MATHEMATICAL MODEL FOR THE DESCRIPTION OF OTHER PHENOMENA.**

**Enduring Understanding 6.A: A wave is a traveling disturbance that transfers energy and momentum.**

Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal.

Essential Knowledge 6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum.

Essential Knowledge 6.A.3: The amplitude is the maximum displacement of a wave from its equilibrium value.

Essential Knowledge 6.A.4: Classically, the energy carried by a wave depends upon and increases with amplitude. Examples should include sound waves.

**Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.**

Essential Knowledge 6.B.1: For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time.

Essential Knowledge 6.B.2: For a periodic wave, the wavelength is the repeat distance of the wave.

Essential Knowledge 6.B.4: For a periodic wave, wavelength is the ratio of speed over frequency.

Essential Knowledge 6.B.5: The observed frequency of a wave depends on the relative motion of source and observer. This is a qualitative treatment only.

## AP PHYSICS II – H

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL QUESTIONS

#### **Enduring Understanding 6.D: Interference and superposition lead to standing waves and beats.**

- Essential Knowledge 6.D.1: Two or more wave pulses can interact in such a way as to produce amplitude variations in the resultant wave. When two pulses cross, they travel through each other; they do not bounce off each other. Where the pulses overlap, the resulting displacement can be determined by adding the displacements of the two pulses. This is called superposition.
- Essential Knowledge 6.D.2: Two or more traveling waves can interact in such a way as to produce amplitude variations in the resultant wave.
- Essential Knowledge 6.D.3: Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. Examples should include waves on a fixed length of string, and sound waves in both closed and open tubes.
- Essential Knowledge 6.D.4: The possible wavelengths of a standing wave are determined by the size of the region to which it is confined.
- Essential Knowledge 6.D.5: Beats arise from the addition of waves of slightly different frequency.

### LEARNING OBJECTIVES

- 1.B.1.1 Make claims about natural phenomena based on conservation of electric charge.
- 1.B.1.2 Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
- 1.B.2.1 Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.
- 1.B.3.1 Challenge the claim that an electric charge smaller than the elementary charge has been isolated.
- 1.C.3.1 Design a plan for collecting data to measure gravitational mass and to measure inertial mass, and distinguish between the two experiments.
- 1.E.2.1 Choose and justify the selection of data needed to determine resistivity for a given material.
- 2.B.1.1 Apply  $F=mg$  to calculate the gravitational force on an object with mass  $m$  in a gravitational field of strength  $g$  in the context of the effects of a net force on objects and systems.
- 2.B.2.1 Apply  $g = G M/r^2$  to calculate the gravitational field due to an object with mass  $M$  where the field is a vector directed toward the center of the object of mass  $M$
- 2.B.2.2 Approximate a numerical value of the gravitational field ( $g$ ) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects.
- 3.A.3.1 Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.
- 3.C.1.1 Use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion.
- 3.C.1.2 Use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion
- 3.C.2.1 Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges
- 3.C.2.2 Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.



## AP PHYSICS II – H

### LEARNING OBJECTIVES

- 3.F.1.1 Use representations of the relationship between force and torque
- 3.F.1.2 Compare the torques on an object caused by various forces
- 3.F.1.3 Estimate the torque on an object caused by various forces in comparison to other situations
- 3.F.1.4 Design an experiment and analyze data testing a question about torques in a balanced rigid system
- 3.F.1.5 Calculate torques on a two-dimensional system in static equilibrium by examining a representation or model
- 3.F.2.1 Make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis.
- 3.F.2.2 Plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis.
- 3.F.3.1 Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum
- 3.F.3.2 Justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object
- 3.F.3.3 Plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object.
- 3.G.1.1 Articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored.
- 4.A.1.1 Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively
- 4.A.2.1 Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time
- 4.A.2.3 Create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system
- 4.A.3.1 Apply Newton's second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system
- 4.A.3.2 Use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system
- 4.D.1.1 Describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system
- 4.D.1.2 Plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data.
- 4.D.2.1 Describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems.
- 4.D.2.2 Plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems.

## AP PHYSICS II – H LEARNING OBJECTIVES

- 4.D.3.1 Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum
- 4.D.3.2 Plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted
- 5.B.9.1 Construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule.)
- 5.B.9.2 Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches.
- 5.B.9.3 Apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch.
- 5.C.3.1 Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed.
- 5.C.3.2 Design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed.
- 5.C.3.3 Use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit.
- 5.E.1.1 Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque.
- 5.E.1.2 Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero
- 5.E.2.1 Describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Do qualitative reasoning with compound objects. Do calculations with a fixed set of extended objects and point masses.

## AP PHYSICS II – H

### UNIT 1: ELECTROSTATICS AND SIMPLE CIRCUITS

#### Big Ideas:

- 1.B: Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.
- 1.E: Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.
- 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 5.B: The energy of a system is conserved.
- 5.C: The electric charge of a system is conserved.

#### Essential Questions

- What is lightning, and why is it so dangerous?*
- What are the fundamental carriers of electrical charge, and how may they be used to charge objects?*
- How is gravitational force similar to electrical force, and in what ways are these forces very different?*
- How are voltage, current, and resistance related in a series circuit?*
- How are voltage, current, and resistance related in a simple parallel circuit?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.</li> <li>▪ There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge</li> <li>▪ The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.</li> <li>▪ Matter has a property called</li> </ul>	<p>Students work in small groups to a construct a very basic parallel circuit (with only one pair of branches), using provided instructions. They then discover the relationships between voltage, current, and resistance for (1) the circuit as a whole, (2) each branch of the circuit, and (3) each individual resistor.</p> <p>Working in small groups, students use rods, cloths of various materials, and an electroscope to draw conclusions about various kinds of interactions between electric charges, as well as to discover the charges imparted to different materials by rubbing with different cloths. Students</p>	<ul style="list-style-type: none"> <li>▪ Make claims about natural phenomena based on conservation of electric charge.1.B.1.2</li> <li>▪ Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.</li> <li>▪ Challenge the claim that an electric charge smaller than the elementary charge has been isolated.</li> <li>▪ Choose and justify the selection of data needed to determine resistivity for a given material.</li> <li>▪ Use Coulomb’s law qualitatively and quantitatively to make predictions about the interaction between two electric point charges</li> <li>▪ Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.</li> </ul>

**AP PHYSICS II – H**  
**UNIT 1: ELECTROSTATICS AND SIMPLE CIRCUITS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>resistivity.</p> <ul style="list-style-type: none"> <li>▪ Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.</li> <li>▪ Kirchhoff’s loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff’s laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors</li> <li>▪ Kirchhoff’s junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady–state situations. For circuits with capacitors, situations should be limited to open circuit, just after circuit is closed, and a long time after the circuit is closed.]</li> </ul>	<p>must first be shown how the electroscope works and how to charge materials through rubbing.</p> <p>To get students thinking about charges, conservation of electrical charge, and the basis of natural phenomena involving static electricity, a Van de Graaff generator is utilized for basic demonstrations involving a variety of objects.</p>	<ul style="list-style-type: none"> <li>▪ Construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff’s loop rule.)</li> <li>▪ Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff’s loop rule in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches.</li> <li>▪ Apply conservation of energy (Kirchhoff’s loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch.</li> <li>▪ Apply conservation of electric charge (Kirchhoff’s junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed.</li> <li>▪ Design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed.</li> <li>▪ Use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit.</li> </ul>

## AP PHYSICS II – H

### UNIT 2: TORQUE AND ROTATIONAL MOTION

#### Big Ideas:

- 3.F: A force exerted on an object can cause a torque on that object.
- 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where  $\rho \rho a F m = \Sigma$ .
- 4.D: A net torque exerted on a system by other objects or systems will change the angular momentum of the system.
- 5.E: The angular momentum of a system is conserved.

#### Essential Questions

- What are the conditions necessary for two people with significant differences in mass to balance on a seesaw?*
- What are the conditions necessary for static equilibrium?*
- In what ways are rotational motion and linear motion related?*
- What are the relationships among angular momentum, angular velocity, angular acceleration, rotational inertia, and torque?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis.</li> <li>▪ The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.</li> <li>▪ A torque exerted on an object can change the angular momentum of an object.</li> <li>▪ The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.</li> <li>▪ Torque, angular velocity, angular</li> </ul>	<p>Working in groups, students analyze and predict the motion of two adjacent merry-go-round analogs when a popper toy is used to exert a force from one onto the other in two situations:</p> <ol style="list-style-type: none"> <li>1. From the bottom of the left-hand merry-go-round to the bottom of the right-hand merry-go-round (viewed from above)</li> <li>2. Along a line tangent to the circles, from one onto the other, where the adjacent merry-go-rounds touch</li> </ol> <p>Working in small groups, students use a playground merry-go-round to investigate how the application of an external torque affects the angular velocity and angular momentum of an</p>	<ul style="list-style-type: none"> <li>▪ Use representations of the relationship between force and torque.</li> <li>▪ Compare the torques on an object caused by various forces.</li> <li>▪ Estimate the torque on an object caused by various forces in comparison to other situations.</li> <li>▪ Design an experiment and analyze data testing a question about torques in a balanced rigid system.</li> <li>▪ Calculate torques on a two-dimensional system in static equilibrium by examining a representation or model.</li> <li>▪ Make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis.</li> <li>▪ Plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that</li> </ul>

**AP PHYSICS II – H**  
**UNIT 2: TORQUE AND ROTATIONAL MOTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>acceleration, and angular momentum are vectors and can be characterized as positive or negative depending upon whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis.</p> <ul style="list-style-type: none"> <li>▪ The angular momentum of a system may change due to interactions with other objects or systems.</li> <li>▪ The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.</li> <li>▪ If the net external torque exerted on the system is zero, the angular momentum of the system does not change.</li> <li>▪ The angular momentum of a system is determined by the locations and velocities of the objects that make up the system. The rotational inertia of an object or system depends upon the distribution of mass within the object or system. Changes in the radius of a system or in the distribution of mass within the system result in changes in the system’s rotational inertia, and hence in its angular velocity and linear</li> </ul>	<p>object. Once students believe they have a qualitative idea of the relationship, they must collect and analyze data to support their conclusions quantitatively.</p> <p>“Lady Bug: Angular Kinematics,” a guided-inquiry activity that involves the “Ladybug Revolution” simulation, is used to help students discover the basics of rotational kinematics. Angular velocity, angular acceleration, and the relationships of the angular kinematic equations to their linear counterparts are investigated.</p>	<p>object about an axis.</p> <ul style="list-style-type: none"> <li>▪ Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum.</li> <li>▪ Justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object.</li> <li>▪ Plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object.</li> <li>▪ Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively.</li> <li>▪ Describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system.</li> <li>▪ Plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data.</li> <li>▪ Describe a model of a rotational system and use that model to analyze a situation in which angular</li> </ul>

**AP PHYSICS II – H**  
**UNIT 2: TORQUE AND ROTATIONAL MOTION**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
<p>speed for a given angular momentum. Examples should include elliptical orbits in an Earth–satellite system. Mathematical expressions for the moments of inertia will be provided where needed. Students will not be expected to know the parallel axis theorem.</p>		<p>momentum changes due to interaction with other objects or systems.</p> <ul style="list-style-type: none"> <li>▪ Plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems.</li> <li>▪ Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum.</li> <li>▪ Plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted.</li> <li>▪ Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque.</li> <li>▪ Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero.</li> <li>▪ Describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Do qualitative reasoning with compound objects. Do calculations with a fixed set of extended objects and point masses.</li> </ul>

## AP PHYSICS II – H

### UNIT 3: GRAVITATIONAL AND CIRCULAR MOTION

#### Big Ideas:

- 1.C: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
- 2.B: A gravitational field is caused by an object with mass.
- 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.
- 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where  $\rho a F m = \Sigma$ .

#### Essential Questions

*Why do you stay in your seat on a roller coaster when it goes upside down in a vertical loop?*  
*How is the motion of a falling apple similar to that of the moon in orbit around the Earth?*  
*What conditions are necessary for a planet to obtain a circular orbit around its host star?*  
*How can Newton's second law of motion be related to the universal law of gravitation?*  
*How can the motion of the center of mass of a system be altered?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.</li> <li>▪ A gravitational field <math>g</math> <math>\gamma</math> at the location of an object with mass <math>m</math> causes a gravitational force of magnitude <math>mg</math> to be exerted on the object in the direction of the field.</li> <li>▪ The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of</li> </ul>	<p>Students working in small groups use the simulation to investigate how a planet's mass, velocity, and distance from a star are related to the planet's orbit. Then they must predict a correct combination of parameters (mass, velocity, and distance) necessary to maintain a circular orbit around a star of whatever mass they choose. Students back up their prediction by deriving an equation relating the universal law of gravitation to centripetal force (showing their calculations) and by using the simulation to test their prediction.</p> <p>Students working in small groups utilize the PhET simulation to do the following:</p>	<ul style="list-style-type: none"> <li>▪ Design a plan for collecting data to measure gravitational mass and to measure inertial mass, and distinguish between the two experiments.</li> <li>▪ Apply <math>F=mg</math> to calculate the gravitational force on an object with mass <math>m</math> in a gravitational field of strength in the context of the effects of a net force on objects and systems.</li> <li>▪ Apply <math>g =GM/r^2</math> to calculate the gravitational field due to an object with mass <math>M</math> where the field is a vector directed toward the center of the object of mass <math>M</math>.</li> <li>▪ Approximate a numerical value of the gravitational field (<math>g</math>) near the surface of an</li> </ul>



**AP PHYSICS II – H**  
**UNIT 3: GRAVITATIONAL AND CIRCULAR MOTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>that object.</p> <ul style="list-style-type: none"> <li>▪ A force exerted on an object is always due to the interaction of that object with another object.</li> <li>▪ Gravitational force describes the interaction of one object that has mass with another object that has mass.</li> <li>▪ Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.</li> <li>▪ The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.</li> <li>▪ Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center-of-mass velocity of that system.</li> </ul>	<ol style="list-style-type: none"> <li>1. Discover the relationship between masses of objects, the distance between them, and the gravitational force of attraction.</li> <li>2. Derive an equation that relates mass, distance, and the gravitational force of attraction.</li> <li>3. Determine the magnitude of the universal gravitational constant.</li> </ol> <p>Then, they must test their equation by determining the gravitational force exerted on their body by the Earth and comparing this force to their known weight in newtons. Finally, students are asked to use their equation and Newton’s second law to derive an equation and solve for the gravitational field (<math>g</math>) at the Earth’s surface.</p> <p>Students working in small groups are challenged to determine the relationships among centripetal acceleration, centripetal force, mass, velocity, and radius. Students accomplish this using a device that they build based on provided instructions. They use the device to swing a rubber stopper at various speeds while keeping a hanging mass (another rubber stopper) stationary. The device has a fishing line threaded through a PVC pipe with rubber stoppers tied to both ends. Students carefully swing the upper stopper in a circle of constant radius while</p>	<p>object from its radius and mass relative to those of the Earth or other reference objects.</p> <ul style="list-style-type: none"> <li>▪ Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.</li> <li>▪ Use Newton’s law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion.</li> <li>▪ Use Newton’s law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion.</li> <li>▪ Articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored.</li> <li>▪ Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.</li> <li>▪ Create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate</li> </ul>

**AP PHYSICS II – H**  
**UNIT 3: GRAVITATIONAL AND CIRCULAR MOTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
	watching the lower (stationary) stopper to ensure it does not bob up and down.	properties of the motion of the center of mass of a system. <ul style="list-style-type: none"> <li>▪ Apply Newton’s second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system.</li> <li>▪ Use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system.</li> </ul>

**AP PHYSICS II – H**  
**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: Electrostatics and Simple Circuits	X	
Unit 2: Torque and Rotational Motion	X	>
Unit 3: Gravitational and Circular Motion		X

## AP PHYSICS II – H COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## AP PHYSICS II – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **ENVIRONMENTAL SCIENCE – S COURSE DESCRIPTION**

### **ENVIRONMENTAL SCIENCE – S**

CREDIT: ½ credit

This course focuses on environmental issues and how they impact students and the community. Students will study biospheres and examine how ecosystems work and how humans are affecting these ecosystems. Topics include water quality, pollution, waste management and recycling, alternative energy sources, endangered species and habitats, local flora and fauna, and current environmental issues at the state, national and global level.

## ENVIRONMENTAL SCIENCE – S

### UNIT 1: HOW ECOSYSTEMS WORK

#### Essential Questions

*How do organisms obtain and use the matter and energy they need to live and grow?*

*How do matter and energy move through an ecosystem?*

*How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. (HS-LS2-4)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-4), (HS-LS2-5)</li> <li>▪ The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis (<i>secondary to HS-LS2-5</i>)</li> <li>▪ Photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus oxygen. (HS-LS1-5)</li> <li>▪ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)</li> <li>▪ Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscle cells and other cells. Cellular respiration also releases the energy needed for homeostasis such as maintaining body temperature (HS-LS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ecological Pond Succession</li> <li>▪ Energy in the Ecosystem Webquest</li> <li>▪ Biome research/presentations</li> <li>▪ Textbook readings</li> <li>▪ Notes/discussion</li> <li>▪ Active Reading: Env &amp; Society</li> <li>▪ Painted Lady Butterfly Biomass Transfer project</li> <li>▪ Active Reading: Everything is Connected</li> <li>▪ Carbon cycle models &amp; discussion of how C cycle can be altered</li> <li>▪ Duck Pond Field Trip</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5)</li> <li>▪ Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (HS-LS2-4)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 1: HOW ECOSYSTEMS WORK**

<b>Grade Level Expectations            Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning            S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Photosynthesis and cellular respiration provide most of the energy for life processes. (HS-LS2-3)</li> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)</li> <li>▪ Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.(HS-LS1-7),(HS-LS2-4)</li> <li>▪ Energy drives the cycling of matter within and between systems. (HS-LS2-3)</li> </ul>		

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 2: INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS**

**Essential Questions**

*How do organisms interact with the living and nonliving environments to obtain matter and energy? (grade band endpoint 12, p.152 Framework)*  
*How is human activity impacting the environment?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Ecosystems have carrying capacities which result from such factors as the availability of finite living and nonliving resources and from such challenges such as predation, competition, and disease. (HS-LS2-1),(HS-LS2-2)</li> <li>▪ Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. (HS-LS2-2),(HS-LS2-6)</li> <li>▪ Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)</li> <li>▪ Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-6)</li> <li>▪ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (<i>secondary to HS-LS2-7</i>)</li> </ul>	<ul style="list-style-type: none"> <li>▪ NASA: Keeping up with Carbon video (C cycle &amp; climate change; greenhouse effect) <a href="http://www.youtube.com/watch?v=Hrllr3xDhQ0E">http://www.youtube.com/watch?v=Hrllr3xDhQ0E</a></li> <li>▪ Oh deer! Carrying Capacity Simulation</li> <li>▪ Dilemma Derby</li> <li>▪ An Inconvenient Truth video (Al Gore documentary on global warming)</li> <li>▪ Graphical representation of predator/prey interactions (Rabbit/lynx game)</li> <li>▪ Life After People video &amp; questions</li> <li>▪ DDT journal entry</li> <li>▪ Wolves video &amp; journal entry</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales (HS-LS2-1)</li> <li>▪ Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales(HS-LS2-2)</li> <li>▪ Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem (HS-LS2-6)</li> </ul>



**ENVIRONMENTAL SCIENCE – S**  
**UNIT 2: INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. <i>(secondary to HS-LS2-7), (HS-LS4-6)</i></li> <li>▪ When evaluating solutions to mitigate adverse impacts of human activity on biodiversity, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. <i>(secondary to HS-LS2-7), (secondary to HS-LS4-6)</i></li> <li>▪ Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. <i>(secondary to HS-LS4-6)</i></li> </ul>		<ul style="list-style-type: none"> <li>▪ Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity (HS-LS4-6)</li> <li>▪ Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity (HS-LS2-7)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 3: TAKING CARE OF OUR WATER RESOURCES**

**Essential Questions**

*What are the causes of water pollution?*

*What are the effects of water pollution on organisms and on the planet?*

*What can be done to reduce water pollution?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)</li> <li>▪ The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)</li> <li>▪ Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS-ESS3-6)</li> <li>▪ Resource availability has guided the development of human society (HS-ESS3-1)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Wastewater Treatment Plant FT (Veolia)</li> <li>▪ Salmon Release &amp; Macroinvertebrate survey FT</li> <li>▪ After the Storm video</li> <li>▪ Giovanni Drive (Jordan Cove) Urban Watershed Project FT</li> <li>▪ Non-point source pollution video</li> <li>▪ Blue Gold Water Wars video</li> <li>▪ Macroinvertebrate Dichotomos key lab</li> <li>▪ Notes/discussion</li> <li>▪ Textbook readings</li> <li>▪ Water Quality lab</li> <li>▪ Oil spill cleanup lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Based upon its properties, provide examples of how water has helped to shape the earth’s surface and its continued effect on the Earth’s materials (HS-ESS2-5)</li> <li>▪ Analyze data to make valid scientific claims that one change to Earth’s surface creates feedbacks that cause changes to other Earth systems (HS-ESS2-2)</li> <li>▪ Use a model to show how variations in the flow of energy into and out of Earth’s systems result in climate change (HS-ESS2-4)</li> <li>▪ Analyze data from global climate models to forecast the current rate of global or regional climate change and associated future impacts to Earth systems (HS-ESS3-5)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 3: TAKING CARE OF OUR WATER RESOURCES**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Technologies can be developed that produce less pollution and waste and that prevent ecosystem degradation (HS-ESS-4)</li> <li>▪ Through computer simulations and other studies, discoveries are still being made about how the ocean, atmosphere &amp; biosphere interact and are modified in response to human activities (HS-ESS3-6)</li> <li>▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics &amp; to consider social, cultural and environmental impacts (HS-ETS1-3), (secondary to HS-ESS3-2 and HS-ESS3-4)</li> <li>▪ Though the magnitude of human impacts are greater than ever, so too are abilities to model, predict and manage current and future impacts (HS-ESS3-5)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Exxon-Valdez oil spill article and video</li> <li>▪ Can the Gulf Survive? (Deepwater Horizon oil spill video) &amp; questions</li> <li>▪ Poison Pump lab</li> <li>▪ Arctic National Wildlife Refuge journal entry</li> <li>▪ Pigeon River journal entry</li> <li>▪ Florida Sinkholes journal entry</li> <li>▪ Invasive Aquatic Species research &amp; wanted poster</li> </ul>	<ul style="list-style-type: none"> <li>▪ Construct an explanation for how natural resources, natural hazards and climate change have influenced human activity (HS-ESS3-1)</li> <li>▪ Create a model to show the relation between natural resource management, human sustainability and biodiversity (HS-ESS3-3)</li> <li>▪ Evaluate or refine a solution to reduce impacts of human activities on natural systems (HS-ESS3-4)</li> <li>▪ Use results from a published model to show relationships among Earth systems and how humans are modifying these relationships (HS-ESS3-6)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4, HS-ESS3-1)</li> </ul>		

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 4: ATMOSPHERE AND AIR POLLUTION**

**Essential Questions**  
*What are the causes of air pollution?*  
*What are the effects of air pollution on organisms and on the planet?*  
*What can be done to reduce air pollution?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-4)(HS-ESS2-7)</li> <li>▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)</li> <li>▪ Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)</li> <li>▪ Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.(HS-LS2-5)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved.(HS-LS2-4)</li> <li>▪ Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS-ESS3-6)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Radish acid rain lab</li> <li>▪ Air Quality Index websites</li> <li>▪ Dangers of Common Household Products Project</li> <li>▪ Giant Sequoia Tree article &amp; questions</li> <li>▪ Notes/discussion</li> <li>▪ Textbook Reading</li> <li>▪ pH lab</li> <li>▪ Ozone video &amp; questions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will be able to compile and compare data sets on carbon dioxide and temperature concentrations over time and use this data to predict future changes in temperature based on current carbon dioxide productions (HS-ESS3-6)</li> <li>▪ Analyze data to make valid scientific claims that one change to Earth’s surface creates feedbacks that cause changes to other Earth systems (HS-ESS2-2)</li> <li>▪ Use a model to show how variations in the flow of energy into and out of Earth’s systems result in climate change (HS-ESS2-4)</li> <li>▪ Analyze data from global climate models to forecast the current rate of global or regional climate change and associated future impacts to Earth systems (HS-ESS3-5)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 4: ATMOSPHERE AND AIR POLLUTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> <li>▪ Technologies can be developed that produce less pollution and waste and that prevent ecosystem degradation (HS-ESS-4)</li> <li>▪ Through computer simulations and other studies, discoveries are still being made about how the ocean, atmosphere &amp; biosphere interact and are modified in response to human activities (HS-ESS3-6)</li> <li>▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics &amp; to consider social, cultural and environmental impacts (HS-ETS1-3), (secondary to HS-ESS3-2 and HS-ESS3-4)</li> </ul>		<ul style="list-style-type: none"> <li>▪ Construct an explanation for how natural resources, natural hazards and climate change have influenced human activity (HS-ESS3-1)</li> <li>▪ Create a model to show the relation between natural resource management, human sustainability and biodiversity (HS-ESS3-3)</li> <li>▪ Evaluate or refine a solution to reduce impacts of human activities on natural systems (HS-ESS3-4)</li> <li>▪ Use results from a published model to show relationships among Earth systems and how humans are modifying these relationships (HS-ESS3-6)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 5: BIOLOGICAL DIVERSITY SURVEY OF CONNECTICUT**

**Essential Questions**

*What are the advantages of having a biodiverse planet?*  
*How are human activities threatening biodiversity?*  
*What can we do to help ensure biodiversity in the future?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> <li>▪ Ecosystems have carrying capacities which result from such factors as the availability of finite living and nonliving resources and from such challenges such as predation, competition, and disease. (HS-LS2-1),(HS-LS2-2)</li> <li>▪ Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. (HS-LS2-2),(HS-LS2-6)</li> <li>▪ Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)</li> <li>▪ Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-6)</li> <li>▪ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).</li> </ul>	<ul style="list-style-type: none"> <li>▪ Survey of Biodiversity in CT: Fish/               <ul style="list-style-type: none"> <li>○ Salmon</li> <li>○ Mammals</li> <li>○ Amphibians</li> <li>○ Reptiles</li> <li>○ Birds</li> </ul> </li> <li>▪ Textbook reading</li> <li>▪ Endangered/ Extinct Species research presentation</li> <li>▪ What is Biodiversity journal entry</li> <li>▪ Public Policy/Laws on saving species journal entry</li> <li>▪ Barn Island FT</li> <li>▪ DPNC Denison Pequotsepos Nature Center)FT or visit by DPNC to WHS</li> </ul>	<ul style="list-style-type: none"> <li>▪ Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)</li> <li>▪ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors. (HS-ESS3-2)</li> <li>▪ Create a model to show the relation between natural resource management, human sustainability and biodiversity (HS-ESS3-3)</li> <li>▪ Evaluate or refine a solution to reduce impacts of human activities on natural systems (HS-ESS3-4)</li> </ul>

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 5: BIOLOGICAL DIVERSITY SURVEY OF CONNECTICUT**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p><i>(secondary to HS-LS2-7)</i></p> <ul style="list-style-type: none"> <li>▪ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. <i>(secondary to HS-LS2-7), (HS-LS4-6)</i></li> <li>▪ When evaluating solutions to mitigate adverse impacts of human activity on biodiversity, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. <i>(secondary to HS-LS2-7),(secondary to HS-LS4-6)</i></li> <li>▪ Both physical models and computers are used to aid in the engineering design process. Computers are useful for running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. <i>(secondary to HS-LS4-6)</i></li> </ul>		<ul style="list-style-type: none"> <li>▪ Use results from a published model to show relationships among Earth systems and how humans are modifying these relationships (HS-ESS3-6)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)</li> <li>▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</li> </ul>		

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 5: BIOLOGICAL DIVERSITY SURVEY OF CONNECTICUT**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ESS3-2)</li> </ul>		



**ENVIRONMENTAL SCIENCE – S**  
**UNIT 6: ENERGY AND WASTE MANAGEMENT**

**Essential Questions**

*How can human societies manage natural resources in a responsible, sustainable manner?*

*What alternative energy sources are there to using coal, oil and natural gas?*

*How can human societies better manage waste?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Resource availability has guided the development of human society (HS-ESS3-1)</li> <li>▪ All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS-2)</li> <li>▪ Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS-1)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> <li>▪ Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)</li> <li>▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Alternative energy research project presentations</li> <li>▪ Human Footprint video</li> <li>▪ Too Hot Not to Handle video (renewable energy sources)</li> <li>▪ Renewable Energy video and discussion</li> <li>▪ Notes/discussion</li> <li>▪ Textbook reading</li> </ul>	<ul style="list-style-type: none"> <li>▪ Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)</li> <li>▪ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors. (HS-ESS3-2)</li> <li>▪ Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (HS-LS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)</li> </ul>		

**ENVIRONMENTAL SCIENCE – S**  
**UNIT 6: ENERGY AND WASTE MANAGEMENT**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)</li> <li>▪ Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)</li> <li>▪ Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)</li> <li>▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)</li> <li>▪ Analysis of costs and benefits is a critical aspect of decisions about - (HS-ESS3-2)</li> </ul>		

## ENVIRONMENTAL SCIENCE – S RESOURCES

- Holt Environmental Science Teacher Edition 2013
- Holt Environmental Science Student Edition textbook 2013
- Holt McDougal Environmental Science Online Interactive Edition 6 Year 2013
- Holt Environmental Science Student One Stop CD-ROM 2013
- Holt Environmental Science Teacher One Stop DVD-ROM
- Holt Environmental Science Study Guide Concept Review
- Holt Environmental Science Lab Generator CD-ROM
- National Geographic Magazine, Discover Magazine and articles from other print sources such as newspapers, scientific journals
- various online sources: videos, web quests, articles
- various DVD videos
- Holt, Rinehart & Winston Environmental Science Student/Teacher Edition textbook 2000

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter
Unit 1: How Ecosystems Work	X	
Unit 2: Interdependent Relationships in Ecosystems	X	
Unit 3: Taking Care of Our Water Resources	X	
Unit 4: Atmospheres and Air Pollution		X
Unit 5: Biological Diversity Survey of Connecticut		X
Unit 6: Energy and Waste Management		X

## ENVIRONMENTAL SCIENCE – S COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## ENVIRONMENTAL SCIENCE – S COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **AP ENVIRONMENTAL SCIENCE – H COURSE DESCRIPTION**

### **AP ENVIRONMENTAL SCIENCE – H**

CREDIT: 1 credit

AP environmental science is a course that incorporates various scientific disciplines in the context of practical real-world issues. This advanced placement course provides students with scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them. Students will have the opportunity to take the AP exam in May.

## AP ENVIRONMENTAL SCIENCE – H EXAM TOPIC OUTLINE

- I. Earth Systems and Resources (Units 1-4) (10-15%)**
  - A. Earth Science Concepts
  - B. The Atmosphere
  - C. Global Water Resources & Use
  - D. Soil & Soil Dynamics
  
- II. The Living World (Unit 1) (10-15%)**
  - A. Ecosystem Structure
  - B. Energy Flow
  - C. Ecosystem Diversity
  - D. Natural Ecosystem Change
  - E. Natural Biogeochemical Cycles
  
- III. Population (Unit 7) (10-15%)**
  - A. Population Biology Concepts
  - B. Human Population
    - 1. Human population dynamics
    - 2. Population size
    - 3. Impacts on population growth
  
- IV. Land and Water Use (Unit 2, 4, 5, 6) (10-15%)**
  - A. Agriculture
    - 1. Feeding a growing population
    - 2. Controlling pests
  - B. Forestry
  - C. Rangelands
  - D. Other Land Use
    - 1. Urban land development
    - 2. Transportation infrastructure
    - 3. Public & federal lands
    - 4. Land conservation options
    - 5. Sustainable land-use strategies
  - E. Mining
  - F. Fishing
  - G. Global Economics
  
- V. Energy Resources & Consumption (Unit 1, 5) (10-15%)**
  - A. Energy Concepts
  - B. Energy Consumption
    - 1. History
    - 2. Present global energy use
    - 3. Future energy needs
  - C. Fossil Fuel Resources & Use
  - D. Nuclear Energy
  - E. Hydroelectric Conservation
  - F. Energy Conservation
  - G. Renewable Energy
  
- VI. Pollution (Unit 2, 3, 4, 5, 6) (25-30%)**
  - A. Pollution Types
    - 1. Air pollution
    - 2. Noise pollution
    - 3. Water pollution
    - 4. Solid waste
  - B. Impacts on the Environment & Human Health
    - 1. Hazards to human health
    - 2. Hazardous chemicals in the environment
  - C. Economic Impacts
  
- VII. Global Change (Unit 3, 4, 7) (10-15%)**
  - A. Stratospheric Ozone
  - B. Global Warming
  - C. Loss of Biodiversity
    - 1. Habitat loss; overuse; pollution; introduced species; endangered & extinct species
    - 2. Maintenance through conservation
    - 3. Relevant laws & treaties

## AP ENVIRONMENTAL SCIENCE – H UNIT 1: ECOLOGY

<p><b>AP Environmental Themes</b>  <i>Science is a process</i>  <i>Energy conversions underlie all ecological processes</i>  <i>The Earth itself is one interconnected system</i></p>
---

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. (HS-LS2-4)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-4), (HS-LS2-5)</li> <li>▪ The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis (<i>secondary to HS-LS2-5</i>)</li> <li>▪ The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)</li> <li>▪ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)</li> <li>▪ Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to cells. (HS-LS1-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cane Toads Video</li> <li>▪ Labs               <ul style="list-style-type: none"> <li>○ Tree biodiversity</li> <li>○ Mark Recapture</li> <li>○ Primary Consumer</li> <li>○ Carrying Capacity</li> </ul> </li> <li>▪ Textbook readings</li> <li>▪ “Moose, Wolves Cling to Isle Royale” and other supplemental readings</li> <li>▪ Notes/ discussion</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (HS-LS2-4)</li> </ul>



**AP ENVIRONMENTAL SCIENCE – H  
UNIT 1: ECOLOGY**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Photosynthesis and cellular respiration (including anaerobic respiration) provide most of the energy for homeostasis and other life processes. (HS-LS2-3)</li> <li>▪ There are positive and negative feedback mechanisms in living organisms which help maintain internal conditions within a range even as external conditions change. (HS-LS1-1)</li> </ul> <hr/> <ul style="list-style-type: none"> <li>▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)</li> <li>▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)</li> <li>▪ Energy cannot be created or destroyed—it only moves between place and another place, between objects and/or fields, or between systems.(HS-LS1-7),(HS-LS2-4)</li> <li>▪ Energy drives the cycling of matter within and between systems. (HS-LS2-3)</li> </ul>		

## AP ENVIRONMENTAL SCIENCE – H UNIT 2: WATER

### AP Environmental Themes

*Science is a process*

*The Earth itself is one interconnected system*

*Humans alter natural systems*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS-ESS3-6)</li> <li>▪ Properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.</li> <li>▪ The interaction of wind patterns, ocean currents, and the distribution of land masses result in a global pattern of latitudinal bands of rain forests and deserts.</li> <li>▪ The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)</li> <li>▪ At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon (in different forms) is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-4, HS-LS2-5)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Field Trips               <ul style="list-style-type: none"> <li>○ SEARCH</li> <li>○ Wastewater Treatment Facility</li> </ul> </li> <li>▪ Movies               <ul style="list-style-type: none"> <li>○ After the Storm</li> <li>○ FLOW</li> </ul> </li> <li>▪ Labs               <ul style="list-style-type: none"> <li>○ Lake Dynamics</li> <li>○ Delineating a drainage basin</li> <li>○ Macroinvertebrate Survey</li> <li>○ DO lab (optional)</li> </ul> </li> <li>▪ Notes/discussion</li> <li>▪ Textbook readings</li> <li>▪ “New Mexico’s Dead Zone” and other supplemental readings</li> </ul>	<ul style="list-style-type: none"> <li>▪ Map current flow in Northern and Southern hemispheres.</li> <li>▪ Based upon its properties, provide examples of how water has helped to shape the earth’s surface and its continued effect on the Earth’s materials (HS-ESS2-5)</li> </ul>

**AP ENVIRONMENTAL SCIENCE – H  
UNIT 2: WATER**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. (HS-ESS3-5)</li> <li>▪ Some system changes are irreversible. (HS-ESS3-5)</li> </ul>		

## AP ENVIRONMENTAL SCIENCE – H UNIT 3: ATMOSPHERE

### AP Environmental Themes

*Science is a process*

*Energy conversions underlie all ecological processes*

*The Earth itself is one interconnected system*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS-ESS2-4)</li> <li>▪ The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-4)(HS-ESS2-7)</li> <li>▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)</li> <li>▪ Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)</li> <li>▪ Differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.</li> <li>▪ The rotation of Earth influences the circular motions of ocean currents and air.</li> <li>▪ The interaction of wind patterns, ocean currents, and the distribution of land masses result in a global pattern of latitudinal bands of rain forests and deserts.</li> </ul>	<ul style="list-style-type: none"> <li>▪ What changes the seasons? model</li> <li>▪ Biome questions</li> <li>▪ Labs:               <ul style="list-style-type: none"> <li>○ Combustion in automobiles</li> <li>○ How Clean is the Air</li> </ul> </li> <li>▪ Movies               <ul style="list-style-type: none"> <li>○ El Nino</li> <li>○ The 11th Hour/ 6 Degrees Could Change the World</li> </ul> </li> <li>▪ Notes/discussion</li> <li>▪ Textbook Reading</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will use heat lamps and spheres to analyze how the angle of insolation impacts temperature at various locations on the sphere and use this model to change orbital angle and distance and relate it to previous climate changes in Earth’s history.</li> <li>▪ Students will be able to compile and compare data sets on carbon dioxide and temperature concentrations over time and use this data to predict future changes in temperature based on current carbon dioxide productions.</li> <li>▪ Develop a model that relates Hadley cells to regional climates that include deserts, rainforests, and other biomes. (HS-ESS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)</li> </ul>		

**AP ENVIRONMENTAL SCIENCE – H  
UNIT 3: ATMOSPHERE**

<b>Grade Level Expectations</b> <b>Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning</b> <b>S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. (HS-ESS3-5)</li> <li>▪ Some system changes are irreversible. (HS-ESS3-5)</li> </ul>		<ul style="list-style-type: none"> <li>▪ Map current flow in Northern and Southern hemispheres.</li> <li>▪ Draw a diagram of global wind patterns and relate them to Hadley cells and the rotation of the Earth.</li> </ul>

## AP ENVIRONMENTAL SCIENCE – H UNIT 4: NATURAL RESOURCES

### AP Environmental Themes

*Science is a process*

*Energy conversions underlie all ecological processes*

*The Earth itself is one interconnected system*

*Humans alter natural systems*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)</li> <li>▪ Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)</li> <li>▪ The radioactive decay of unstable isotopes continually generates new energy within Earth’s crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)</li> <li>▪ The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)</li> <li>▪ The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it. (HS-ESS2-7)</li> </ul>	<ul style="list-style-type: none"> <li>▪ National parks/Monuments</li> <li>▪ Endangered Species Project</li> <li>▪ Soil Lab- many parts</li> <li>▪ notes/discussion</li> <li>▪ Textbook reading</li> <li>▪ CITES/ESA and other supplemental readings</li> </ul>	<ul style="list-style-type: none"> <li>▪ Show examples of how variations in one earth system can have profound influences on another. (HS-ESS2-3), (HS-ESS2-6)</li> <li>▪ Describe the cycling of matter and energy through the earth’s interior. (HS-ESS2-3)</li> <li>▪ Describe the cycling of carbon through the earth’s spheres. (HS-ESS2-3)</li> <li>▪ Construct a model of the earth’s interior based upon evidence from various technologies and geologic comparisons (HS-ESS2-3). (HS-ESS2-6)</li> <li>▪ Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)</li> </ul>

**AP ENVIRONMENTAL SCIENCE – H  
UNIT 4: NATURAL RESOURCES**

<p align="center"><b>Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i></b></p>	<p align="center"><b>Instructional Strategies</b></p>	<p align="center"><b>Evidence of Learning S and E Practices <i>Students will be able to:</i></b></p>
<ul style="list-style-type: none"> <li>▪ Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (HS-ESS2-3)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> </ul>		
<ul style="list-style-type: none"> <li>▪ The total amount of energy and matter in the carbon cycled is conserved. (HS-ESS2-6)</li> <li>▪ Energy drives the cycling of matter within and between systems on Earth (HS-ESS2-3).</li> <li>▪ The functions and properties of natural and designed objects during chemical weathering and other systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)</li> <li>▪ How to explain the coevolution of the Earth’s systems and life on Earth. (HS-ESS2-7)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. One change to the Earth’s surface can create feedbacks that cause changes to other Earth systems.(HS-ESS2-2)</li> <li>▪ Science and engineering complement each other in the cycle known as research and development (R&amp;D). Many R&amp;D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)</li> <li>▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)</li> </ul>		

## AP ENVIRONMENTAL SCIENCE – H UNIT 5: ENERGY AND WASTE

### AP Environmental Themes

*Science is a process*

*Energy conversions underlie all ecological processes*

*The Earth itself is one interconnected system*

*Environmental problems have a cultural and social context*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Resource availability has guided the development of human society (HS-ESS3-1)</li> <li>▪ All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS-2)</li> <li>▪ Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS-1)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> <li>▪ Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)</li> <li>▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Alternative energy presentation</li> <li>▪ Trash movie</li> <li>▪ Trash and recycling inventory and other calculations</li> <li>▪ Notes/discussion</li> <li>▪ Textbook reading</li> </ul>	<ul style="list-style-type: none"> <li>▪ Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)</li> <li>▪ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors. (HS-ESS3-2)</li> <li>▪ Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (HS-LS2-4)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)</li> </ul>		



**AP ENVIRONMENTAL SCIENCE – H  
UNIT 5: ENERGY AND WASTE**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i></b>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices <i>Students will be able to:</i></b>
<ul style="list-style-type: none"> <li>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)</li> <li>▪ Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)</li> <li>▪ Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)</li> <li>▪ Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)</li> <li>▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)</li> <li>▪ Analysis of co and benefits is a critical aspect of decisions about -ESS3-2)</li> </ul>		

## AP ENVIRONMENTAL SCIENCE – H

### UNIT 6: TOXICOLOGY, PESTICIDES AND AGRICULTURE

#### AP Environmental Themes

*Science is a process*

*The Earth itself is one interconnected system*

*Humans alter natural systems*

*Human survival depends on developing practices that will achieve sustainable yield*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Resource availability has guided the development of human society (HS-ESS3-1)</li> <li>▪ All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS-2)</li> <li>▪ Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS-1)</li> <li>▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Labs:               <ul style="list-style-type: none"> <li>○ LD 50 with Brine Shrimp</li> </ul> </li> <li>▪ Movies               <ul style="list-style-type: none"> <li>○ Food Inc./ King Corn</li> </ul> </li> <li>▪ Notes/Discussion</li> <li>▪ Textbook reading</li> </ul>	<ul style="list-style-type: none"> <li>▪ Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)</li> <li>▪ Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)</li> <li>▪ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors. (HS-ESS3-2)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)</li> <li>▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</li> <li>▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ESS3-2)</li> </ul>		

## AP ENVIRONMENTAL SCIENCE – H UNIT 7: POLITICS AND ECONOMICS

### AP Environmental Themes

*Science is a process*

*The Earth itself is one interconnected system*

*Humans alter natural systems*

*Environmental problems have a cultural and social context.*

*Human survival depends on developing practices that will achieve sustainable yield*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS-ESS2-4)</li> <li>▪ The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-4)(HS-ESS2-7)</li> <li>▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)</li> <li>▪ Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)</li> <li>▪ Differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.</li> <li>▪ The rotation of Earth influences the circular motions of ocean currents and air.</li> <li>▪ The interaction of wind patterns, ocean currents, and the distribution of land masses result in a global pattern of latitudinal bands of rain forests and deserts.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Categorize the quote-environmental worldview</li> <li>▪ Labs:               <ul style="list-style-type: none"> <li>○ Tragedy of the Commons</li> <li>○ Designing a sustainable city</li> <li>○ World population and doubling time graphs</li> </ul> </li> <li>▪ Notes/discussion</li> <li>▪ Textbook reading</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will use heat lamps and spheres to analyze how the angle of insolation impacts temperature at various locations on the sphere and use this model to change orbital angle and distance and relate it to previous climate changes in Earth’s history.</li> <li>▪ Students will be able to compile and compare data sets on carbon dioxide and temperature concentrations over time and use this data to predict future changes in temperature based on current carbon dioxide productions.</li> <li>▪ Develop a model that relates Hadley cells to regional climates that include deserts, rainforests, and other biomes. (HS-ESS2-4)</li> </ul>

**AP ENVIRONMENTAL SCIENCE – H**  
**UNIT 7: POLITICS AND ECONOMICS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)</li> <li>▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. (HS-ESS3-5)</li> <li>▪ Some system changes are irreversible. (HS-ESS3-5)</li> </ul>		<ul style="list-style-type: none"> <li>▪ Map current flow in Northern and Southern hemispheres.</li> <li>▪ Draw a diagram of global wind patterns and relate them to Hadley cells and the rotation of the Earth.</li> </ul>

## AP ENVIRONMENTAL SCIENCE – H RESOURCES

- o Book- Living in the Environment- 18th edition by G. Tyler Miller and Scott E. Spoolman
- o Assorted videos
- o Magazine and internet articles listed in instructional strategies

### PACING GUIDE

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter
Unit 1: Ecology	X			
Unit 2: Water	X			
Unit 3: Atmosphere		X		
Unit 4: Natural Resources		X		
Unit 5: Energy and Waste			X	
Unit 6: Toxicology, Pesticides, and Agriculture			X	
Unit 7: Politics and Economics				X
Research Project				X

## AP ENVIRONMENTAL SCIENCE – H COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## AP ENVIRONMENTAL SCIENCE – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### *Mathematics*

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **ANATOMY & PHYSIOLOGY – A COURSE DESCRIPTION**

### **ANATOMY & PHYSIOLOGY – A**

CREDIT: 1 credit

This course is open to students who have successfully completed Biology and either Chemistry for Future Presidents or Physics for Future Presidents or its equivalent, and who have an interest in the human body and how it works. Those students with an interest in pursuing a career in an allied health field will particularly benefit from the course. The major emphasis is on the anatomy and function of the various body systems, with a minimal focus on the biochemistry. Desirable outcomes will include a thorough understanding of the anatomy of the human body, from cells to tissues to organ systems; recognizing how the systems behave in both health and disease, as well as improved laboratory skills, techniques and procedures. It is expected that students will participate in actual dissections.



## ANATOMY & PHYSIOLOGY – A

### UNIT 1: INTRODUCTION TO ANATOMY AND PHYSIOLOGY AND THE INTEGUMENTARY SYSTEM

#### Essential Questions

*How is the body organized for anatomical reference and study?*

*What is the difference between cells, tissues and organs?*

*What are stem cells and what are the advantages/and or disadvantages associated with pursuing therapies?*

*What tissues make up the human body?*

*How does the structure of the skin relate to its many functions?*

*What causes skin to age?*

*What kinds of jobs are available for students pursuing careers related to anatomy?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Anatomy and physiology are complimentary sciences that allow one to study, classify, and understand body structures and functions.</li> <li>▪ Cells are a complex assemblage of interacting and changing chemical, physical and biological processes.</li> <li>▪ Cells vary considerably in size, shape and function. The shapes of cells make possible their functions.</li> <li>▪ Tissues are groups of cells with specialized structural and functional roles. The human body is made up of four major types of tissues: epithelial, connective, muscle and nervous.</li> <li>▪ The skin, the largest organ in the body, provides a protective, waterproof barrier for the body. This cutaneous membrane and its accessory structures play a vital role</li> </ul>	<ul style="list-style-type: none"> <li>▪ Stem cell webquest</li> <li>▪ Create a specialized cell poster or cell booklet representing a typical cell from each of the 11 body systems.</li> <li>▪ Career project- Using various career information websites, students will explore health related careers and create visual presentations for the class.</li> <li>▪ Quizzes</li> <li>▪ Tests</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Various labs Including:               <ul style="list-style-type: none"> <li>○ Using Anatomical Language</li> <li>○ Medical Terminology Basics</li> <li>○ Hair and Fiber Analysis</li> <li>○ Fingerprinting</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Outline the levels of structural organization that make up the human body and explain how they are related.</li> <li>▪ Apply proper anatomical terminology to describe body directions, surfaces, and body planes.</li> <li>▪ Locate the major body cavities, and list the chief organs in each.</li> <li>▪ Describe or demonstrate anatomical position.</li> <li>▪ Identify the organelles on a cell diagram and discuss the major function of each.</li> <li>▪ Define the following: selective permeability, diffusion, osmosis, active transport, passive transport, solute pumping, exocytosis, phagocytosis, and pinocytosis.</li> <li>▪ Describe the structure of the plasma membrane and explain how various transport processes account for the directional movements of specific substances across the plasma membrane.</li> <li>▪ Identify various cell types, and relate their overall shape and internal structure to their specific functions.</li> <li>▪ Identify the four major tissue types and their chief subcategories and explain how the four major tissue types differ structurally and functionally.</li> </ul>

**ANATOMY & PHYSIOLOGY – A**

**UNIT 1: INTRODUCTION TO ANATOMY AND PHYSIOLOGY AND THE INTEGUMENTARY SYSTEM**

<p align="center"><b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i></p>	<p align="center"><b>Instructional Strategies</b></p>	<p align="center"><b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i></p>
<p>in helping the body to maintain homeostasis.</p> <ul style="list-style-type: none"> <li>▪ Skin is a dynamic organ that changes throughout our lifetime from both environmental factors as well as the aging process.</li> </ul>	<ul style="list-style-type: none"> <li>○ Tissue labs- involving microscopic examination of each of the four tissue types and their subcategories</li> <li>○ Skin Lab</li> <li>▪ Internet research on various diseases</li> <li>▪ Cat Dissection</li> <li>▪ Labeling diagrams</li> <li>▪ Function charts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Illustrate and label subcategories of the major tissue types while observing them under a microscope</li> <li>▪ List several important functions of the integumentary system and explain how these functions are accomplished.</li> <li>▪ When provided with a diagram of the skin, recognize and name the following structures: epidermis, dermis (papillary and reticular layers), hair and hair follicles, sebaceous gland, sweat gland and arrector pili muscle.</li> <li>▪ Name the layers of the epidermis and dermis and describe the characteristics of each.</li> <li>▪ Describe the distribution and function of the skin’s accessory organs, including: sebaceous glands, sweat glands, hair and nails.</li> <li>▪ Name the factors that determine skin color and describe the function of melanin.</li> <li>▪ Recognize the importance of Vitamin D production by the skin and how it relates to one’s overall health.</li> <li>▪ Describe wound healing.</li> <li>▪ Differentiate among a 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> degree burn and explain the importance of the “Rules of Nine”.</li> <li>▪ Describe changes that happen to the skin and its structures as we age.</li> <li>▪ Identify common diseases/disorders of the skin.</li> <li>▪ Identify careers in the health care related field and categorized them by income, education required and current need.</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 1: INTRODUCTION TO ANATOMY AND PHYSIOLOGY AND THE INTEGUMENTARY SYSTEM**

**RESOURCES**

- Textbook : Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Essentials of Human Anatomy & Physiology*. 12th ed. New York: McGraw Hill Higher Education, 2015. with Connect Plus (ISBN#978-0-02-137837-1)
- Body Atlas Video- Skin
- Microscopes
- Tissue slides
- Fingerprinting kits
- Hair and Fiber Analysis kits

## ANATOMY & PHYSIOLOGY – A

### UNIT 2: SUPPORT AND MOVEMENT

#### Essential Questions

*What are the major bones and tissues of the skeletal system and what are their functions?*

*How does a broken bone heal?*

*What are the names of the major muscle groups of the body and what kinds of movement do they allow?*

*How does a muscle actually contract and produce movement?*

*What are some common diseases/disorders associated with both the skeletal and muscular systems?*

*What can I do to maintain normal bone and muscle health throughout my lifetime?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The skeletal system provides an internal framework for the body, protects soft organs, and allows for movement of body extremities through the use of skeletal muscle.</li> <li>▪ The muscular system is responsible for body movements, maintaining posture, generating heat, and stabilizing joints.</li> <li>▪ Muscles and bones are dynamic tissues that can change throughout your lifetime through both internal and external stimuli.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Skeleton project- labeled, life sized drawing of a skeleton- identifying major bone names, subcategories of major bones and bone markings</li> <li>▪ Muscle Project- Identification of 40 different muscles on pictures of body builders</li> <li>▪ Quizzes</li> <li>▪ Tests</li> <li>▪ Homework- hard copy and online</li> <li>▪ Various Labs, including:</li> <li>▪ Internet research on diseases of the musculoskeletal system</li> <li>▪ Cat Dissection</li> <li>▪ Class presentations on muscle functions</li> <li>▪ Labeling diagrams</li> <li>▪ Function charts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Explain the functions of the skeletal and muscular systems.</li> <li>▪ Identify the types of cells and tissues found within the framework of the skeleton.</li> <li>▪ Identify all of the names of bones that comprise both the axial and appendicular skeleton.</li> <li>▪ Identify the structures of a long bone and describe the functions of those structures.</li> <li>▪ Differentiate between the bones of the vertebral column and describe 3 abnormal spinal curvatures.</li> <li>▪ Describe the mechanics of maintaining a normal/ healthy posture.</li> <li>▪ Describe the effects of diet, exercise and age on the health of bones.</li> <li>▪ Describe the process of bone formation and growth (both longitudinal and appositional).</li> <li>▪ Describe the different types of bone fractures and repair.</li> <li>▪ Describe the characteristic differences in the skeletal features of a newborn, teenager and adult.</li> <li>▪ Differentiate between a male and female pelvis and</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 2: SUPPORT AND MOVEMENT**

<b>Grade Level Expectations            Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning            S and E Practices</b> <i>Students will be able to:</i>
		identify the reasons for the difference. <ul style="list-style-type: none"> <li>▪ Relate the structure of the different types of joints to the types of movements they allow.</li> <li>▪ Identify the major synovial joints by name and type of movement.</li> <li>▪ Discuss common diseases of the skeletal and muscular systems.</li> <li>▪ Describe the microscopic structure of the three types of muscle cells.</li> <li>▪ Describe the major events that occur during muscle fiber contraction.</li> <li>▪ Describe the structure and function of the neuromuscular junction and motor unit.</li> <li>▪ Identify the energy pathways by which a muscle obtains ATP.</li> <li>▪ Identify the locations and describe the movement produced by the major skeletal muscles.</li> <li>▪ Correlate skeletal and muscle movements with various body positions and movements.</li> <li>▪ Explain the effects of exercise on muscle health.</li> </ul>

## **ANATOMY & PHYSIOLOGY – A**

### **UNIT 2: SUPPORT AND MOVEMENT**

#### **RESOURCES**

- Textbook : Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Essentials of Human Anatomy & Physiology*. 12th ed. New York: McGraw Hill Higher Education, 2015. with Connect Plus (ISBN#978-0-02-137837-1)
- Discovery Channel School Video - The Musculoskeletal System
- Discovery Channel School Video- Inside Look: Broken Bone
- Body Atlas Video- Muscle and Bone
- “Who Owns These Bones” lab kits
- Skeleton models
- Joint models
- X-ray pictures
- Access to computers
- iPad apps for skeletal system and muscular system
- Cats

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 3: NERVOUS AND CHEMICAL CONTROL (NERVOUS AND ENDOCRINE SYSTEMS)**

**Essential Questions**

*How does the central and peripheral nervous system respond to internal and external stimuli?*

*How is a nerve impulse conducted?*

*What parts of the brain are responsible for various body functions and actions?*

*How do each of the sense organs receive stimuli and transmit it to the nervous system?*

*How do endocrine glands exert control over major physiological responses?*

*What role do hormones have in maintaining homeostasis within the body?*

*What are some of the major diseases associated with the nervous or endocrine systems?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The brain is a very complex organ, with different regions responsible for specific functions.</li> <li>▪ The nervous system is responsible for all body actions, responses, sensations and emotions in its attempt to maintain homeostasis.</li> <li>▪ The endocrine system works to ensure proper growth, development, reproduction and metabolism within the body.</li> <li>▪ The functions of the nervous and endocrine systems enable us to interact with and respond to our environment (both internal and external).</li> </ul>	<ul style="list-style-type: none"> <li>▪ Class presentations on the sensory organs and their functions</li> <li>▪ Endocrine power point presentations by students- covering location of glands, hormones secreted, actions of hormones on target organs, regulation of hormones and disease associated with those glands</li> <li>▪ Quizzes</li> <li>▪ Tests</li> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Sheep brain dissection</li> <li>2. Nervous System Lab</li> <li>3. Reflex Lab</li> <li>4. Eye Lab</li> <li>5. Balance Lab</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Differentiate among structures found in the central and peripheral nervous system.</li> <li>▪ Identify the principal parts of the brain and describe the functions of each.</li> <li>▪ Describe the general structure of a motor neuron.</li> <li>▪ Compare and contrast different types of neurons in terms of location, structure and function.</li> <li>▪ Explain the mechanism of synaptic transmission and describe the types and effects of the most important neurotransmitter.</li> <li>▪ Describe the events that lead to the generation of a nerve impulse.</li> <li>▪ Describe the function and importance of neuroglial cells.</li> <li>▪ Explain the role of the blood-brain barrier.</li> <li>▪ Distinguish between parasympathetic and sympathetic divisions of the autonomic nervous system in their actions.</li> <li>▪ Identify the parts of a reflex arc.</li> <li>▪ Identify and describe the function of structures found</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 3: NERVOUS AND CHEMICAL CONTROL (NERVOUS AND ENDOCRINE SYSTEMS)**

<b>Grade Level Expectations                      Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning                      S and E Practices</b> <i>Students will be able to:</i>
	<p style="text-align: center;">6. Taste and Smell Lab</p> <ul style="list-style-type: none"> <li>▪ Homework- hard copy and online</li> <li>▪ Internet research on diseases associated with the nervous system and special senses</li> <li>▪ Cat dissection</li> <li>▪ Labeling Diagrams</li> <li>▪ Function charts</li> </ul>	<p>in the eye and ear.</p> <ul style="list-style-type: none"> <li>▪ Trace the pathway through which light travels as it passes from the cornea to the retina.</li> <li>▪ Trace the pathway of sound vibrations from the outer ear to the cochlea.</li> <li>▪ Identify the structures within the ear responsible for static and dynamic equilibrium.</li> <li>▪ Identify at least 4 different types of sensory receptors and describe the functions of each.</li> <li>▪ Describe the interrelationship between the sense of smell and the sense of taste.</li> <li>▪ Name the basic taste sensations and describe the patterns in which receptors are distributed on the tongue.</li> <li>▪ Name and locate the major endocrine glands and identify the hormones they secrete.</li> <li>▪ Describe the effects of various hormones on the body's systems.</li> <li>▪ Describe the negative feedback system and how it regulates hormonal secretions.</li> <li>▪ Explain the role of the nervous system in the control of hormonal secretions.</li> <li>▪ Identify major diseases of the nervous system and special senses.</li> <li>▪ Identify common disease of the endocrine system.</li> </ul>



**ANATOMY & PHYSIOLOGY – A**  
**UNIT 3: NERVOUS AND CHEMICAL CONTROL (NERVOUS AND ENDOCRINE SYSTEMS)**

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Essentials of Human Anatomy & Physiology*. 12th ed. New York: McGraw Hill Higher Education, 2015. with Connect Plus (ISBN#978-0-02-137837-1)
- Body Atlas Video- The Brain, Now Hear This, Visual Reality, Glands and Hormones
- Discovery Channel School Video- Understanding the Amazing Brain
- Sheep Brains
- Brain models
- Spinal cord segment model
- Reflex hammers
- Reaction timers, rulers
- Finger mazes
- Snellen charts
- Astigmatism charts
- Flashlights
- Sense of Smell Lab-Aids Kits
- Access to computers

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 4: BLOOD AND THE CARDIOVASCULAR SYSTEM**

**Essential Questions**

- What makes blood red?*
- Is blood the same in every human?*
- What are the major structures of the circulatory system?*
- What pathway does the blood follow as it circulates through the heart and the body?*
- How does a wound stop bleeding?*
- What makes the sound of one’s heartbeat?*
- What do the numbers in one’s blood pressure mean? What is a normal blood pressure?*
- What is an ECG and what is it used for?*
- What causes a heart attack?*
- What behaviors and activities can I do to improve my cardiovascular fitness?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The cardiovascular system, consisting of the heart and blood vessels, provides oxygen and nutrients to and removes waste from body cells.</li> <li>▪ Blood is a type of connective tissue in which cells are suspended in an extracellular matrix. It transports substances between body cells and the external environment, and helps maintain a stable internal environment.</li> <li>▪ Proper diet and exercise are paramount in maintaining the health of the cardiovascular system.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Tests</li> <li>▪ Homework- hard copy and online</li> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Sheep heart dissection.</li> <li>2. Pulse Lab</li> <li>3. Forensics lab- “Whodunit” – using blood typing techniques to identify the perpetrator of a crime</li> <li>4. Blood pressure lab- students learn to manually take blood pressure on each other and determine the effects of exercise on blood pressure, heart rate, and respiratory rates</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Describe the composition and volume of blood.</li> <li>▪ Distinguish among the types of blood cells using their characteristics and functions.</li> <li>▪ Describe how blood clots.</li> <li>▪ Compare and contrast the structure and function of arteries, veins and capillaries.</li> <li>▪ Identify the body’s major arteries and veins.</li> <li>▪ Identify and palpate major pulse sites on the body.</li> <li>▪ Identify the different blood types, their antigens and antibodies.</li> <li>▪ Explain the need for blood compatibility in transfusions and between the fetus and mother during pregnancy.</li> <li>▪ Identify parts of the heart and explain the functions of each part.</li> <li>▪ Explain the role of the intrinsic conduction system.</li> <li>▪ Trace the path of blood through a complete circuit of</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 4: BLOOD AND THE CARDIOVASCULAR SYSTEM**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
	<ul style="list-style-type: none"> <li>▪ Internet research on various cardiovascular diseases</li> <li>▪ Cat Dissection</li> <li>▪ Labeling diagrams</li> <li>▪ Function charts</li> </ul>	<p>the CV system.</p> <ul style="list-style-type: none"> <li>▪ Describe how the systolic and diastolic numbers are derived in taking blood pressure.</li> <li>▪ Define hypertension and atherosclerosis and describe the possible health consequences of these conditions.</li> <li>▪ Discuss factors that affect blood pressure.</li> <li>▪ Correctly take another student’s blood pressure using a stethoscope and blood pressure cuff.</li> <li>▪ Explain how heart rate is regulated.</li> <li>▪ List and describe disorders associated with the CV system.</li> <li>▪ Explain the events leading up to a heart attack and how to reduce one’s risk for myocardial infarction or stroke.</li> <li>▪ Describe the effects of exercise on the CV system.</li> </ul>

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Essentials of Human Anatomy & Physiology*. 12th ed. New York: McGraw Hill Higher Education, 2015. with Connect Plus (ISBN#978-0-02-137837-1)
- Body Atlas Video- The Human Pump, Breath of Life
- Discovery Channel School Video- Inside Look: Heart Attack
- Sheep hearts
- Blood Pressure Cuffs (sphygmomanometers and wrist cuffs)
- Stethoscopes
- Heart Model
- “Whodunit” blood typing kits
- Access to Computer Lab
- Cats

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 5: DIGESTION, RESPIRATION AND EXCRETION**

**Essential Questions**

*How does the digestive system process food into nutrients that can be used by the body?*  
*How does the respiratory system aid in the exchange of gases between the blood and tissues of the body?*  
*What allows us to breathe in and out?*  
*How and why is urine made?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The digestive system mechanically and chemically breaks down food and absorbs the products to give the body the required nutrients to function properly and maintain homeostasis.</li> <li>▪ The role of the respiratory system is to get oxygen to the body tissues and remove carbon dioxide through the process of respiration.</li> <li>▪ The urinary system is responsible for removing wastes from the body via urine, regulating blood pressure with the assistance of chemicals, and regulating blood pH.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Food diaries and diet analysis by individual students</li> <li>▪ Quizzes</li> <li>▪ Homework- hard copy and online</li> <li>▪ Labeling diagrams</li> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Respiration lab- measuring tidal volume, vital capacity, expiratory reserve volume, inspiratory reserve volume, and residual volume.</li> </ol> </li> <li>▪ Internet research on various diseases</li> <li>▪ Cat Dissection</li> <li>▪ Current events articles</li> <li>▪ Function charts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Name the organs of the alimentary canal and accessory digestive organs and identify each on an appropriate diagram.</li> <li>▪ Identify the overall function of the digestive system and describe the general activities of each organ.</li> <li>▪ Describe the basic anatomy of the teeth and oral cavity and explain their functions in relation to digestion.</li> <li>▪ Trace the pathway of digestion from mouth to anus.</li> <li>▪ Describe how foodstuffs in the digestive tract are mixed and moved along the tract.</li> <li>▪ List the major enzymes produced by the digestive organs or accessory glands and name the foodstuffs on which they act.</li> <li>▪ State the end products of protein, fat and carbohydrate digestion.</li> <li>▪ Describe how villi aid digestive processes in the small intestine.</li> <li>▪ Describe the characteristics of an adequate diet.</li> <li>▪ Identify diseases/disorders of the digestive system.</li> <li>▪ Name and locate the organs of the respiratory system and explain the function of each.</li> <li>▪ Describe the events involved in inspiration and</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 5: DIGESTION, RESPIRATION AND EXCRETION**

<b>Grade Level Expectations            Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning            S and E Practices</b> <i>Students will be able to:</i>
		<p>expiration.</p> <ul style="list-style-type: none"> <li>▪ Trace a breath of air through the respiratory system from the nasal cavity to the alveoli in the lungs.</li> <li>▪ Describe the process of gas exchanges in the lungs and tissues.</li> <li>▪ Explain how gases are transported by the blood.</li> <li>▪ Name several physical factors that influence respiratory rate.</li> <li>▪ Define tidal volume, vital capacity, expiratory reserve volume, inspiratory reserve volume, and residual volume.</li> <li>▪ Explain the relative importance of O<sub>2</sub> and CO<sub>2</sub> in modifying the rate and depth of breathing.</li> <li>▪ Locate and label the major organs of the urinary system and discuss the functions of each.</li> <li>▪ Recognize that the nephron is the structural and functional unit of the kidney and describe its anatomy.</li> <li>▪ Describe the composition of normal urine and list abnormal urinary components.</li> <li>▪ Explain how micturation occurs and describe the difference in control of the external and internal urethral sphincters.</li> <li>▪ Explain the role hormones, buffers and others systems play in maintaining a homeostatic balance by the kidneys with the blood.</li> <li>▪ List and describe common diseases/disorders associated the urinary tract.</li> </ul>

**ANATOMY & PHYSIOLOGY – A**  
**UNIT 5: DIGESTION, RESPIRATION AND EXCRETION**

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Essentials of Human Anatomy & Physiology*. 12th ed. New York: McGraw Hill Higher Education, 2015. with Connect Plus (ISBN#978-0-02-137837-1)
- Body Atlas videos- The Food Machine, Breath of Life.
- Lung Volume Bags, Mouthpieces
- Spirometers
- Access to Computers
- Anatomy Torso model with removable organs
- Cats

**ANATOMY & PHYSIOLOGY – A**  
**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter
Unit 1: Introduction to Anatomy and Physiology and Integumentary System	X			
Unit 2: Support and Movement		X		
Unit 3: Nervous and Chemical Control			X	
Unit 4: Blood and the Cardiovascular System			X	>
Unit 5: Digestion, Respiration and Excretion				X
Cat Dissection				X

## ANATOMY & PHYSIOLOGY – A COMMON CORE CONNECTIONS

### ***ELA/Literacy***

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)

## ANATOMY & PHYSIOLOGY – A COMMON CORE CONNECTIONS

- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)
- WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)
- SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

- MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)
- MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)
- HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)
- HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)
- HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)
- HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)
- HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)
- HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)
- HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)
- HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)
- HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)
- HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)



## **ANATOMY & PHYSIOLOGY – H COURSE DESCRIPTION**

### **ANATOMY & PHYSIOLOGY – H**

CREDIT: 1 credit

This course is open to students who have successfully completed Biology and either Chemistry for Future Presidents or Physics for Future Presidents or its equivalent, and who have an interest in the human body and how it works. Those students with an interest in pursuing a career in an allied health field will particularly benefit from the course. The major emphasis is on the anatomy and function of the various body systems, with a minimal focus on the biochemistry. Desirable outcomes will include a thorough understanding of the anatomy of the human body, from cells to tissues to organ systems; recognizing how the systems behave in both health and disease, as well as improved laboratory skills, techniques and procedures. It is expected that students will participate in actual dissections.

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 1: TERMINOLOGY, STRUCTURE, ORGANIZATION, CELLS AND TISSUE**

**Essential Questions**

*What is the relationship between anatomy and physiology?*

*How is homeostasis related to the health of an organism?*

*Why is it important to use the correct anatomical terms?*

*What are the major body cavities and their subdivisions?*

*How is each body system organized?*

*What are the functions of each body system?*

*How is the structure and function of the cell membrane used to regulate the cell?*

*What are the four basic tissues of the body and how is their structure related to their use?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Anatomy and physiology uses a language based in Latin and terminology is important for comprehension and universal communication of material.</li> <li>▪ The structures within the human body can be described, organized and classified for understanding.</li> <li>▪ In the human body, structure dictates function.</li> <li>▪ The normal and most desirable condition of body functioning is homeostasis. Its loss or destruction always leads to some type of pathology- temporary or permanent.</li> <li>▪ The human body has different levels of structural organization with the cell being the most basic unit.</li> <li>▪ Cells are a complex assemblage of interacting and changing chemical, physical and biological processes.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs, including:               <ol style="list-style-type: none"> <li>1. Tissue lab- involving microscopic examination of each of the four tissue types and their subcategories</li> <li>2. Medical Terminology Basics</li> <li>3. Using Anatomical Language</li> </ol> </li> <li>▪ Create a specialized cell poster/ booklet representing a typical cell from each of the 11 body systems.</li> <li>▪ Stem cell webquest</li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Test</li> <li>▪ Homework- both hard copy and online</li> </ul>	<ul style="list-style-type: none"> <li>▪ Explain the relationship between anatomy and physiology, and describe their subdivisions.</li> <li>▪ Apply correct anatomical terms to describe body directions, regions, and body planes or sections.</li> <li>▪ Locate and name the major body cavities and their subdivisions, and list the major organs contained within them.</li> <li>▪ Identify the different levels of structural organization that make up the human body, and explain their relationships.</li> <li>▪ List the 11 organ systems of the body, identify their components, and briefly explain the major function(s) of each.</li> <li>▪ Define homeostasis and explain its significance.</li> <li>▪ Describe how negative feedback and positive feedback maintain body homeostasis.</li> <li>▪ Describe the relationship between homeostatic imbalance and disease.</li> <li>▪ Describe the structure of the plasma membrane and</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 1: TERMINOLOGY, STRUCTURE, ORGANIZATION, CELLS AND TISSUE**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Cells work together to form tissues that can carry out specific functions.</li> <li>▪ Depending on their structure, tissues provide a division of labor for the body's work.</li> <li>▪ All tissues develop from simple layers in the embryo starting from stem cells.</li> <li>▪ Stem cells are important because they have the potential to become almost any kind of cell. Stem cells are used in the body to replaced damaged or worn out cells, but can also provide a basis for therapeutic or regenerative medicine.</li> <li>▪ Each system of the body provides a function for the whole organism and all of the systems are interrelated.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cat Dissection</li> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> </ul>	<p>explain how various transport processes account for the directional movements of specific substances across the plasma membrane.</p> <ul style="list-style-type: none"> <li>▪ Identify the body's four basic tissue types and describe their roles.</li> <li>▪ Discuss the types and functions of epithelial cells.</li> <li>▪ Describe the relationship between form and function for each type of epithelium.</li> <li>▪ Compare the structures and functions of the various types of connective tissues.</li> <li>▪ Explain how epithelial and connective tissues combine to form four types of membranes, and specify the functions of each.</li> <li>▪ Describe the three types of muscle tissue and the distinctive structural features of each.</li> <li>▪ Discuss the basic structure and role of neural tissue.</li> <li>▪ Illustrate, label and identify subcategories of the major tissue types under a microscope.</li> <li>▪ Discuss the benefits, implications and controversies associated with stem cell therapies.</li> </ul>

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. Hole's Human Anatomy & Physiology. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Microscopes
- Histology slides
- Human torso model
- Access to computers
- ADAM on Demand computer program- Cell Biology

## ANATOMY & PHYSIOLOGY – H

### UNIT 2: INTEGUMENTARY SYSTEMS

#### Essential Questions

- What are the functions of skin?*
- What tissue types make up the epidermis and dermis?*
- What are the major layers of the epidermis and dermis?*
- What are the functions of each layer of the epidermis and dermis?*
- What contributes to skin color?*
- What is the structure and location of the sweat and oil glands?*
- What is the composition and function of the secretions of the sweat and oil glands?*
- What are the similarities and differences between the eccrine and apocrine glands?*
- What are the parts of the hair follicle and their functions?*
- Why do different people have different hair colors?*
- Does hair continuously grow throughout our lifetime?*
- What are nails made of?*
- Which skin cancers are the most dangerous?*
- How can you tell if a burn is serious?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The skin provides a protective, waterproof barrier for the body whose integrity is essential to maintaining a healthy body.</li> <li>▪ The skin’s appendages (derivatives)- including nails, hair, sweat and oil glands- each have unique roles in maintaining homeostasis.</li> <li>▪ Skin is a dynamic organ that changes throughout our lifetime from both environmental factors as well as the aging process.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Hair and Fiber Analysis Lab</li> <li>2. Skin Lab- including fingerprint analysis, labeling the parts of the nail, analyzing microscopic slides of the skin, and testing the sweat glands and sensory receptor activity</li> </ol> </li> <li>▪ Student/ class generated homeostatic imbalances of skin powerpoints</li> <li>▪ Labeling diagrams</li> </ul>	<ul style="list-style-type: none"> <li>▪ Describe how skin accomplishes at least 5 different functions.</li> <li>▪ Name the tissue types composing the epidermis and dermis.</li> <li>▪ List the major layers of the epidermis and dermis and describe the function of each layer.</li> <li>▪ Describe the factors that normally contribute to skin color and describe how changes in skin color may be used as clinical signs of certain disease states.</li> <li>▪ Compare the structure and locations of sweat and oil glands, as well as compare the composition and function of their secretions.</li> <li>▪ Compare and contrast eccrine and apocrine glands.</li> <li>▪ List the parts of a hair follicle and explain the function</li> </ul>

## ANATOMY & PHYSIOLOGY – H UNIT 2: INTEGUMENTARY SYSTEMS

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
	<ul style="list-style-type: none"> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Test</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> </ul>	<p>of each part.</p> <ul style="list-style-type: none"> <li>▪ Name the regions of a hair and explain the basis of hair color.</li> <li>▪ Describe the distribution, growth, replacement and changing nature of hair during the life span.</li> <li>▪ Describe the structure and composition of the parts of nails.</li> <li>▪ Summarize the three major types of skin cancers.</li> <li>▪ Explain how to differentiate between first, second and third degree burns and explain why serious burns are life threatening.</li> <li>▪ Describe and attempt to explain the causes of changes that occur in the skin from birth to old age.</li> </ul>

### RESOURCES

- Shier, David, Jackie Butler, and Ricki Lewis. Hole's Human Anatomy & Physiology. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Body Atlas Video- Skin
- Microscopes
- Hair and Fiber Analysis kit
- Fingerprinting kit
- slides
- prepared slides
- ADAM on Demand computer program
- Access to computers
- Cats

## ANATOMY & PHYSIOLOGY – H UNIT 3: SKELETAL SYSTEM

### Essential Questions

*What is bone made of?*

*How does our skeleton change throughout our lifetime?*

*How do broken bones heal?*

*What things can I do throughout my lifetime to maintain bone density?*

*How do forensic scientists determine sex, race and age from skeletal bones?*

*How does my knee joint differ from the joints in my fingers or shoulder or ankles?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The skeletal system is composed of various cells and tissues and chemical components with specific functions that work together to provide our bodies with support, protection, movement, growth and blood cell formation.</li> <li>▪ Bone is a dynamic and active tissue that is able to form and remodel throughout one’s life.</li> <li>▪ Imbalances between bone formation and resorption underlie all skeletal disorders.</li> <li>▪ The axial and appendicular segments of the skeleton contain distinctive structures that have important roles for the body.</li> <li>▪ Prognosis and treatment for fractures depends on fracture type, age and health of the individual.</li> <li>▪ Joints have different compositions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. The Skeleton System Lab</li> <li>2. Forensic bone activity- “Who Owns These Bones”- identifying sex, race and height from three bones</li> <li>3. Articulations and Body Movements</li> </ol> </li> <li>▪ Skeleton project- specifically labeled, life sized drawing of a skeleton</li> <li>▪ Internet research on diseases of the skeletal system.</li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Test</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> </ul>	<ul style="list-style-type: none"> <li>▪ List and describe the five important functions of bone</li> <li>▪ Identify the major bones that are part of the axial and appendicular skeletal divisions.</li> <li>▪ Identify the different types of bones, including long, short, flat, irregular, and sesamoid bone.</li> <li>▪ Describe the gross anatomy of a typical long and flat bone</li> <li>▪ Discuss the chemical composition of bone</li> <li>▪ Compare and contrast compact to spongy bone.</li> <li>▪ Distinguish between epiphyseal growth (length) and appositional growth (thickness).</li> <li>▪ Understand that bone remodeling is an ongoing process replacing old bone tissue with new.</li> <li>▪ Describe the different types of bone fractures and repair.</li> <li>▪ Understand calcium homeostasis in bones.</li> <li>▪ Describe the effects of exercise on bone tissue.</li> <li>▪ Explain the impact of aging on bone.</li> <li>▪ Identify the major bone markings (processes and depressions).</li> </ul>

## ANATOMY & PHYSIOLOGY – H UNIT 3: SKELETAL SYSTEM

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
and shapes enabling varying levels of mobility.	<ul style="list-style-type: none"> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> </ul>	<ul style="list-style-type: none"> <li>▪ Compare and contrast the structures of the male and female skeletons</li> <li>▪ Classify and demonstrate joints according to their degree and type of movement.</li> <li>▪ Identify major articulations in the body.</li> </ul>

### RESOURCES

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Human Anatomy & Physiology*. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Discovery Channel School Video- Inside Look: Broken Bone
- Body Atlas Video- Muscle and Bone
- 2 fully articulated skeleton models- one real, one synthetic
- box of disarticulated bones
- “Who Owns These Bones” kits
- X-ray pictures
- Joint models
- Access to computers
- Cats
- Skeleton program apps on iPads
- ADAM on Demand

## ANATOMY & PHYSIOLOGY – H UNIT 4: MUSCULAR SYSTEM

### Essential Questions

- What is the structure and function of the three types of muscle tissue?*  
*Where is each type of muscle tissue found?*  
*What is the role of actin and myosin containing filaments?*  
*What are the key steps involved in the contraction of skeletal muscle fiber?*  
*How are muscles named?*  
*What is the general function of the major skeletal muscles?*  
*What are the similarities of aerobic and anaerobic endurance?*  
*What is muscle fatigue?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The body contains three types of muscles, each with a unique structure and function. In all its forms muscle makes up half of the body’s mass.</li> <li>▪ The muscular system is responsible for body movements, maintaining posture, generating heat, and stabilizing joints.</li> <li>▪ Skeletal muscle is a discrete organ, made up of several kinds of tissues including blood, nerves, connective tissue and predominating skeletal fibers (both gross and microscopic).</li> <li>▪ A muscle contraction is a complex series of steps that involves nerves and the chemical and physical interactions of various structures.</li> <li>▪ Muscles can be named for their location, their fiber direction or how</li> </ul>	<ul style="list-style-type: none"> <li>▪ Muscle information and coloring packets</li> <li>▪ Students are assigned specific muscles and present locations and functions to classmates</li> <li>▪ Muscle project- Label 60 muscles covered in class on pictures of body builders</li> <li>▪ Internet research on diseases of the muscular system</li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Test</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> <li>▪ ADAM on Demand</li> </ul>	<ul style="list-style-type: none"> <li>▪ Identify the general functions of the muscular system.</li> <li>▪ Describe the four functional characteristics of muscle tissue. (elasticity, excitability, extensibility, flexibility).</li> <li>▪ Identify the general location, microscopic appearance, control, and functions of the three specific types of muscle tissue. (skeletal, smooth, cardiac).</li> <li>▪ Describe the gross and microscopic structure of muscles as well as their functional roles.</li> <li>▪ Describe the sliding-filament theory of muscle contraction.</li> <li>▪ Define the terms “origin” and “insertion.”</li> <li>▪ Explain the role of prime movers (agonists), antagonists, synergists, and fixators.</li> <li>▪ Locate, identify and describe the functions of the major skeletal muscles.</li> <li>▪ Understand the actions of the muscular and skeletal systems working together to maintain calcium homeostasis.</li> <li>▪ Understand the impact of aging on the muscular</li> </ul>



## ANATOMY & PHYSIOLOGY – H UNIT 4: MUSCULAR SYSTEM

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>they are arranged.</p> <ul style="list-style-type: none"> <li>▪ The most distinguishing functional characteristic of muscles is their ability to transform chemical energy (ATP) into directed mechanical energy.</li> <li>▪ Muscle fatigue is linked to several factors including how fuel is broken down in the body.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Current events articles</li> </ul>	<p>system.</p> <ul style="list-style-type: none"> <li>▪ Describe three ways in which ATP is regenerated during skeletal muscle contraction.</li> <li>▪ Understand the impact of exercise on muscle fatigue.</li> <li>▪ Identify what occurs during muscle fatigue.</li> </ul>

### RESOURCES

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Human Anatomy & Physiology*. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Discovery Channel School Video - The Musculoskeletal System
- Body Atlas Video- Muscle and Bone
- Access to computers
- iPad app for muscles
- Cats
- ADAM on Demand

## ANATOMY & PHYSIOLOGY – H

### UNIT 5: THE NERVOUS SYSTEM AND SENSES

#### Essential Questions

*How does the central and peripheral nervous system respond to internal and external stimuli?*

*How is a nerve impulse conducted?*

*What parts of the brain are responsible for various body functions and actions?*

*How do each of the sense organs receive stimuli and transmit it to the nervous system?*

*How do endocrine glands exert control over major physiological responses?*

*What role do hormones have in maintaining homeostasis within the body?*

*What are some of the major diseases associated with the nervous or endocrine systems?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The brain is a very complex organ, with different regions responsible for specific functions.</li> <li>▪ Nerve cells send electrochemical signals for communication.</li> <li>▪ Structurally and functionally there are 3 classes of neurons- but all serve to transmit impulses to and from the central nervous system.</li> <li>▪ Reflexes help protect our bodies from harm and can be tested.</li> <li>▪ The visual, olfactory and gustatory receptors are found within organs in the head and once stimulated those receptors send impulses to the brain for interpretation.</li> <li>▪ The sense of smell is closely aligned with the sense of taste.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs- including:               <ol style="list-style-type: none"> <li>1. Sheep brain dissection</li> <li>2. Nervous System Lab</li> <li>3. Reflex Lab</li> <li>4. Eye Lab</li> <li>5. Balance Lab</li> <li>6. Taste and Smell Lab</li> </ol> </li> <li>▪ Student generated class presentations on sensory organs</li> <li>▪ Internet research on diseases associated with the nervous system and special senses.</li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Test</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> </ul>	<p><b><u>Nervous System</u></b></p> <ul style="list-style-type: none"> <li>▪ Understand the three main functions of the nervous system – sensory, integrative, and motor.</li> <li>▪ Explain the structural and functional divisions of the nervous system.</li> <li>▪ Identify the structures of a neuron, a synapse, and a neuromuscular junction.</li> <li>▪ Explain the importance of myelination and how it differentiates gray and white matter.</li> <li>▪ Classify neurons structurally and functionally.</li> <li>▪ Understand the role of neurons transmitting electrochemical impulses along axons and across synapses.</li> <li>▪ Graphically illustrate and label an action potential or impulse.</li> <li>▪ Identify major neurotransmitters and neurotransmitter inhibitors.</li> <li>▪ Differentiate among structures found in the central and peripheral nervous system.</li> <li>▪ Identify the major parts of the brain, their function, and</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 5: THE NERVOUS SYSTEM AND SENSES**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
	<ul style="list-style-type: none"> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> </ul>	<p>describe how the brain is protected.</p> <ul style="list-style-type: none"> <li>▪ Describe the formation and circulation of cerebrospinal fluid.</li> <li>▪ Identify the major cranial nerves.</li> <li>▪ Describe the function and importance of neuroglial cells.</li> <li>▪ Explain the role of the blood-brain barrier.</li> <li>▪ Describe protective structures and anatomical features of the spinal cord.</li> <li>▪ Identify the major spinal nerves.</li> <li>▪ Compare the structural and functional differences between the autonomic and somatic nervous system.</li> <li>▪ Distinguish between parasympathetic and sympathetic divisions of the autonomic nervous system in their actions.</li> <li>▪ Describe the functional components of a reflex arc and how it works to maintain homeostasis.</li> <li>▪ Describe the effects of aging on the nervous system.</li> <li>▪ Describe the events involved in damage and repair of peripheral nerves.</li> </ul> <p><b><u>Senses</u></b></p> <ul style="list-style-type: none"> <li>▪ Understand each type of sensory receptor detects a particular kind of stimulus.</li> <li>▪ Describe the structure and function of the olfactory receptors.</li> <li>▪ Describe the structure and function of the gustatory</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 5: THE NERVOUS SYSTEM AND SENSES**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
		receptors. <ul style="list-style-type: none"> <li>▪ Describe the structure and function of the eye and vision.</li> <li>▪ Describe the structure and function of the ear and hearing.</li> <li>▪ Understand the inner ear contains sensory receptors for our sense of equilibrium.</li> <li>▪ Describe age related changes that occur with the special senses.</li> </ul>

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Human Anatomy & Physiology*. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Body Atlas Video- The Brain, Now Hear This, Visual Reality, Glands and Hormones
- Discovery Channel School Video- Understanding the Amazing Brain
- Sheep Brains
- Cow eyeballs
- Brain models
- Spinal cord segment model
- Reflex hammers
- Reaction timers, rulers
- Finger mazes
- Snellen charts
- Astigmatism charts
- Flashlights
- Sense of Smell Lab-Aids Kits
- Otoscopes
- Access to computers

## ANATOMY & PHYSIOLOGY – H

### UNIT 6: THE ENDOCRINE SYSTEMS

#### Essential Questions

*How do endocrine glands exert control over major physiological responses?*

*What role do hormones have in maintaining homeostasis within the body?*

*What are some of the major diseases associated with the nervous or endocrine systems?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The endocrine system is a network of glands that secrete hormones, which travel in the bloodstream and affect the functioning of target cells.</li> <li>▪ The endocrine system works to ensure proper growth, development, reproduction and metabolism within the body.</li> <li>▪ The endocrine and nervous systems work together to maintain homeostasis.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Endocrine power point presentations by students- covering location of glands, hormones secreted, actions of hormones on target organs, regulation of hormones and disease associated with those glands</li> <li>▪ Quizzes</li> <li>▪ Homework- hard copy and online</li> <li>▪ Cat dissection</li> <li>▪ Labeling diagrams</li> <li>▪ Function charts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Name and locate the major endocrine glands and identify the hormones they secrete.</li> <li>▪ Describe the effects of various hormones on the body's systems.</li> <li>▪ Describe the negative feedback system and how it regulates hormonal secretions.</li> <li>▪ Explain the role of the nervous system in the control of hormonal secretions.</li> <li>▪ Identify common disease of the endocrine system.</li> </ul>

### RESOURCES

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Human Anatomy & Physiology*. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Body Atlas Video- The Brain, Now Hear This, Visual Reality, Glands and Hormones
- Access to computers

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 7: BLOOD AND THE CARDIOVASCULAR SYSTEM**

**Essential Questions**

*Why is blood such an important tissue?*

*How does a doctor use a blood test as a diagnostic tool?*

*What are the major structures of the circulatory system?*

*What pathway does the blood follow as it circulates through the heart and the body?*

*What do the numbers in one’s blood pressure mean? What is a normal blood pressure?*

*What information could be gleaned from listening to the heart sounds with a stethoscope?*

*What is an ECG and how is it used as a diagnostic tool?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Blood is a type of connective tissue in which cells are suspended in a liquid extracellular matrix. It serves as a vehicle for distributing body heat and for transporting nutrients, respiratory gases, and other substances throughout the body.</li> <li>▪ The cardiovascular system, consisting of the heart and blood vessels, provides oxygen and nutrients to and removes waste from body cells. The heart pumps the blood and the blood vessels provide the conduits within which blood circulates to all body tissues.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Sheep Heart Dissection</li> <li>2. Blood pressure lab- students learn to manually take blood pressure on each other and determine the effects of exercise on blood pressure, heart rate, and respiratory rate</li> <li>3. Pulse Lab</li> <li>4. Forensics Lab- “Whodunit” – using blood typing techniques to identify the perpetrator of a crime</li> </ol> </li> <li>▪ Internet research on diseases associated with the nervous system and special senses</li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> </ul>	<p><b><u>Blood</u></b></p> <ul style="list-style-type: none"> <li>▪ Describe the general characteristics of blood, and discuss its major functions.</li> <li>▪ Distinguish among the formed elements and the liquid portion of blood.</li> <li>▪ Explain the significance of red blood cell counts.</li> <li>▪ Summarize the control of red blood cell production.</li> <li>▪ Distinguish among the five types of white blood cells, and give the function(s) of each.</li> <li>▪ Describe the functions of each of the major components of plasma.</li> <li>▪ Define hemostasis and explain the mechanisms that help achieve it.</li> <li>▪ Describe the blood-clotting process.</li> <li>▪ Explain blood typing and how it is used to avoid adverse transfusion reactions.</li> <li>▪ Describe how blood reactions may occur between fetal and maternal tissues.</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 7: BLOOD AND THE CARDIOVASCULAR SYSTEM**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
	<ul style="list-style-type: none"> <li>▪ Tests</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> </ul>	<p><b><u>Cardiovascular System</u></b></p> <ul style="list-style-type: none"> <li>▪ Discuss the functions of the organs of the cardiovascular system.</li> <li>▪ Distinguish between the coverings of the heart and the layers that compose the wall of the heart.</li> <li>▪ Identify and locate the major parts of the heart, and discuss the functions of each part.</li> <li>▪ Trace the pathway of blood through the heart and the vessels of the coronary circulation.</li> <li>▪ Describe the cardiac cycle and the cardiac conduction system.</li> <li>▪ Identify the parts of a normal ECG pattern, and discuss the significance of this pattern.</li> <li>▪ Explain the control of the cardiac cycle.</li> <li>▪ Compare the structures and functions of the major types of blood vessels.</li> <li>▪ Describe how substances are exchanged between blood in the capillaries and the tissue fluid surrounding body cells.</li> <li>▪ Explain how blood pressure is produced and controlled.</li> <li>▪ Describe the mechanisms that aid in returning venous blood to the heart.</li> <li>▪ Compare the pulmonary and systemic circuits of the cardiovascular system.</li> <li>▪ Identify and locate the major arteries and veins.</li> <li>▪ Describe changes in the cardiovascular system with aging and list several factors that help maintain cardiovascular health.</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 7: BLOOD AND THE CARDIOVASCULAR SYSTEM**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
		<ul style="list-style-type: none"> <li>▪ List and describe disorders associated with the CV system.</li> </ul>

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. Hole's Human Anatomy & Physiology. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Body Atlas Video- The Human Pump
- Discovery Channel School Video- Inside Look: Heart Attack
- Sheep hearts
- Blood Pressure Cuffs (sphygmomanometers and wrist cuffs)
- “Whodunit” simulated blood typing kits
- Stethoscopes
- Heart Model
- Access to Computer Lab
- Cats



**ANATOMY & PHYSIOLOGY – H**  
**UNIT 8: DIGESTIVE, RESPIRATORY AND URINARY SYSTEMS**

**Essential Questions**

- What is the location and function of each organ in the digestive system?*
- By what processes does food move from the mouth to the cells?*
- What is the location and function of each organ in the respiratory system?*
- What are the four events in respiration?*
- What role does pressure play in breathing?*
- What is the location and function of each organ in the excretory system?*
- How and why is urine formed?*
- What kind of information does a routine urinalysis provide?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Digestion mechanically and chemically breaks down food into particles small enough to be absorbed into the blood. The digestive system consists of an alimentary canal and several accessory organs.</li> <li>▪ The cardiovascular system, consisting of the heart and blood vessels, provides oxygen and nutrients to and removes waste from body cells. The heart pumps the blood and the blood vessels provide the conduits within which blood circulates to all body tissues.</li> <li>▪ The urinary system plays a vital role in the body in removing wastes from the blood and transporting them to the outside as well as maintaining an internal homeostasis. The urinary</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various labs including:               <ol style="list-style-type: none"> <li>1. Measuring Respiration Lab- measuring tidal volume, vital capacity, expiratory reserve, inspiratory reserve, reserve volume, and residual volume</li> <li>2. Simulated Components of Urine Lab</li> </ol> </li> <li>▪ Labeling diagrams</li> <li>▪ Function Charts</li> <li>▪ Quizzes</li> <li>▪ Tests</li> <li>▪ Homework- both hard copy and online</li> <li>▪ Cat Dissection</li> <li>▪ ADAM on Demand</li> <li>▪ Current events articles</li> <li>▪ Internet research on diseases of these systems</li> </ul>	<p><b><u>Digestive System</u></b></p> <ul style="list-style-type: none"> <li>▪ Describe the general functions of the digestive system</li> <li>▪ Describe the functions of the structures associated with the mouth.</li> <li>▪ Locate each of the digestive organs and glands; then describe the general function of each.</li> <li>▪ Identify the function of each enzyme secreted by the digestive organs.</li> <li>▪ Explain how the products of digestion are absorbed.</li> <li>▪ List the major sources of carbohydrates, lipids and proteins in a diet and describe how the cells use these and other nutrients (including vitamins and minerals).</li> <li>▪ Describe some major diseases associated with the digestive system.</li> </ul> <p><b><u>Respiratory System</u></b></p> <ul style="list-style-type: none"> <li>▪ Identify the general functions of the respiratory system.</li> <li>▪ Locate the organs and associated structures of the respiratory system.</li> <li>▪ Describe the functions of each organ of the respiratory</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 8: DIGESTIVE, RESPIRATORY AND URINARY SYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>system removes salts and nitrogenous wastes from the blood, helps maintain normal concentrations of water and electrolytes in body fluids, regulates the pH and volume of body fluids, and helps control red blood cell production and blood pressure.</p>		<p>system.</p> <ul style="list-style-type: none"> <li>▪ Explain the mechanisms of inspiration and expiration.</li> <li>▪ Define each of the respiratory volumes and capacities.</li> <li>▪ Explain how air and blood exchange gases.</li> <li>▪ List the ways blood transports oxygen and carbon dioxide.</li> <li>▪ Describe some major diseases associated with the respiratory system.</li> </ul> <p><b><u>Urinary System</u></b></p> <ul style="list-style-type: none"> <li>▪ List the general functions of the organs of the urinary system.</li> <li>▪ Describe the location, structure and functions of the kidneys.</li> <li>▪ Trace the pathway of blood through the major vessels in the kidney</li> <li>▪ Describe a nephron, and explain the functions of its major parts.</li> <li>▪ Describe the process in which urine is formed.</li> <li>▪ Explain factors that affect and regulate the rate of urine formation.</li> <li>▪ Locate and describe the structure of the ureters, urinary bladder and urethra.</li> <li>▪ Explain the process and control of micturition.</li> <li>▪ Describe the major components of normal urine.</li> <li>▪ Describe some major diseases associated with the urinary system.</li> </ul>

**ANATOMY & PHYSIOLOGY – H**  
**UNIT 8: DIGESTIVE, RESPIRATORY AND URINARY SYSTEMS**

**RESOURCES**

- Shier, David, Jackie Butler, and Ricki Lewis. *Hole's Human Anatomy & Physiology*. 14th ed. New York: McGraw Hill Higher Education, 2016. with Connect Plus 6 year subscription ( ISBN# 978-0-07-671272-4 )
- Body Atlas videos- The Food Machine, Breath of Life.
- Lung Volume Bags, Mouthpieces
- Spirometers
- Simulated Urine lab kit
- Access to Computers
- Anatomy Torso model with removable organs

**ANATOMY & PHYSIOLOGY – H**  
**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter
Unit 1: Terminology, Structure, Organization, Cells and Tissues	X			
Unit 2: The Integumentary System	X			
Unit 3: The Skeletal System		X		
Unit 4: The Muscular System		X		
Unit 5: The Nervous System and the Senses			X	
Unit 6: The Endocrine System			X	
Unit 7: Blood and the Cardiovascular System			X	>
Unit 8: Digestion, Respiration and Urinary Systems				X
Cat Dissection				X

## ANATOMY & PHYSIOLOGY – H COMMON CORE CONNECTIONS

### ***ELA/Literacy***

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## ANATOMY & PHYSIOLOGY – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **UCONN ECE BIOLOGY COURSE DESCRIPTION**

### **UCONN ECE BIOLOGY**

The UCONN ECE biology course covers both the UCONN Biology 1107 and 1108 curriculum. This course integrates the major themes of biological science to give students a deep understanding of the major concepts which run through the discipline. Topics covered include science as process, evolution, energy transfer, continuity and change, regulation, biochemical principals, cell biology and science, technology, and society. Students will have the option to take the biology AP exam in May, although not every enduring understanding from the AP curriculum is covered in this course due to time constraints.

## UCONN ECE BIOLOGY

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL KNOWLEDGE

#### **BIG IDEA 1: THE PROCESS OF EVOLUTION DRIVES THE DIVERSITY AND UNITY OF LIFE.**

##### **Enduring Understanding 1.A: Change in the genetic makeup of a population over time is evolution.**

- Essential knowledge 1.A.1: Natural selection is the major driving mechanism of evolution.
- Essential knowledge 1.A.2: Natural Selection acts on phenotypic variations in populations.
- Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
- Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines including mathematics.

##### **Enduring Understanding 1.B: Organisms are linked by lines of descent from common ancestry.**

- Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
- Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.

##### **Enduring understanding 1.C: Life continues to evolve within a changing environment.**

- Essential knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history.
- Essential knowledge 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.
- Essential knowledge 1.C.3: Populations of organisms continue to evolve.

##### **Enduring understanding 1.D: The origin of living systems is explained by natural processes.**

- Essential knowledge 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
- Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.

#### **BIG IDEA 2: BIOLOGICAL SYSTEMS UTILIZE FREE ENERGY AND MOLECULAR BUILDING BLOCKS TO GROW, TO REPRODUCE, AND TO MAINTAIN DYNAMIC HOMEOSTASIS.**

##### **Enduring understanding 2.A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.**

- Essential knowledge 2.A.1: All living systems require constant input of free energy.
- Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.
- Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.

## UCONN ECE BIOLOGY

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL KNOWLEDGE

**Enduring understanding 2.B:** **Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.**

Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.

Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

**Enduring understanding 2.C:** **Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.**

Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.

Essential knowledge 2.C.2: Organisms respond to changes in their external environments.

**Enduring understanding 2.D:** **Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.**

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

Essential knowledge 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.

**Enduring understanding 2.E:** **Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.**

Essential knowledge 2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.

Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.

Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.

### **BIG IDEA 3: LIVING SYSTEMS STORE, RETRIEVE, TRANSMIT, AND RESPOND TO INFORMATION ESSENTIAL TO LIFE PROCESSES.**

**Enduring understanding 3.A:** **Heritable information provides for continuity of life.**

Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.

Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.



## UCONN ECE BIOLOGY

### BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL KNOWLEDGE

Essential knowledge 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.

Essential knowledge 3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.

#### **Enduring understanding 3.B: Expression of genetic information involves cellular and molecular mechanisms.**

Essential knowledge 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.

Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.

#### **Enduring understanding 3.C: The processing of genetic information is imperfect and is a source of genetic variation.**

Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.

Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.

Essential knowledge 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.

#### **Enduring understanding 3.D: Cells communicate by generating, transmitting and receiving chemical signals.**

Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.

Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.

Essential knowledge 3.D.3: Signal transduction pathways link signal reception with cellular response.

Essential knowledge 3.D.4: Changes in signal transduction pathways can alter cellular response.

#### **Enduring understanding 3.E: Transmission of information results in changes within and between biological systems.**

Essential knowledge 3.E.1: Individuals can act on information and communicate it to others.

Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

### **BIG IDEA 4: BIOLOGICAL SYSTEMS INTERACT, AND THESE SYSTEMS AND THEIR INTERACTIONS POSSESS COMPLEX PROPERTIES.**

#### **Enduring understanding 4.A: Interactions within biological systems lead to complex properties.**

Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

Essential knowledge 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.

Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.

Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.

**UCONN ECE BIOLOGY**  
**BIG IDEAS, ENDURING UNDERSTANDING & ESSENTIAL KNOWLEDGE**

- Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways.  
Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

**Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.**

- Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.  
Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.  
Essential knowledge 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.  
Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.

**Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.**

- Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.  
Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.  
Essential knowledge 4.C.3: The level of variation in a population affects population dynamics.  
Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.

## UCONN ECE BIOLOGY SCIENCE PRACTICES

1. Use representations and models to communicate scientific phenomena and solve scientific problems.
  - a. Create representations and models of natural or manmade phenomena and systems in the domain
  - b. Describe representations and models of natural or manmade phenomena and systems in the domain
  - c. Refine representations and models of natural or manmade phenomena and systems in the domain
  - d. Use representations and models of analyze situations or solve problems qualitatively and quantitatively
  - e. Re-express key elements of natural phenomena across multiple representations in the domain
2. Use mathematics properly
  - a. Justify selection of mathematical routine to solve problems
  - b. Apply mathematical routines to quantities
  - c. Estimate numerical quantities
3. Engage in scientific questioning to extend thinking or to guide investigations within the context of the course
  - a. Pose scientific questions
  - b. Refine scientific questions
  - c. Evaluate scientific questions
4. Plan and implement data collection strategies appropriate to a particular scientific question
  - a. Justify the selection of the kind of data needed to answer a particular scientific question
  - b. Design a plan for collecting data to answer a particular scientific question
  - c. Collect data to answer a particular scientific question
  - d. Evaluate sources of data to answer a particular scientific question
5. Perform data analysis and evaluation of evidence
  - a. Analyze data to identify patterns or relationships
  - b. Refine observations and measurements based on data analysis
  - c. Evaluate the evidence provided by data sets in relation to a particular scientific question
6. Work with scientific explanations and theories
  - a. Justify claims with evidence
  - b. Construct explanations of phenomena based on evidence produced through scientific practices
  - c. Articulate the reasons that scientific explanations and theories are refined or replaced
  - d. Make claims and predictions about natural phenomena based on scientific theories and models
  - e. Evaluate alternative scientific explanations
7. Connect and relate knowledge across various scales, concepts and representations in and across domains
  - a. Connect phenomena and models across spatial and temporal scales
  - b. Connect concepts in and across domains to generalize or extrapolate in and/or across enduring understandings and/or big ideas

**UConn ECE BIOLOGY**  
**UNIT 1: ENERGY TRANSFER/WATER/MACROMOLECULES**

**Objectives:** Big Ideas 2 and 4

**Enduring understanding 2.A:** Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

**Enduring understanding 4.A:** Interactions within biological systems lead to complex properties.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>All living systems require constant input of free energy. <b>(2.A.1)</b></p> <ul style="list-style-type: none"> <li>▪ Life requires a highly ordered system.</li> <li>▪ Living systems do not violate the second law of thermodynamics, which states that entropy increases over time.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Glycolysis</li> <li>▪ Krebs Cycle</li> <li>▪ Endothermy</li> <li>▪ Ectothermy</li> </ul>	<ul style="list-style-type: none"> <li>▪ Order is maintained by constant free energy input into the system.</li> <li>▪ Loss of order or free energy flow results in death.</li> <li>▪ Increased disorder and entropy are offset by biological processes that maintain or increase order.</li> <li>▪ Order is maintained by coupling cellular processes that increase entropy (and so have negative changes in free energy) with those that decrease entropy (and so have positive changes in free energy).</li> <li>▪ Energy input must exceed free energy lost to entropy to maintain order and power cellular processes.</li> <li>▪ Energetically favorable exergonic reactions, such as ATP→ADP, that have a negative change in free energy can be used to maintain or increase order in a system by being coupled with reactions that have a positive free energy change.</li> </ul>
<p><b>Essential knowledge:</b> Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. <b>(2.A.3)</b></p> <ul style="list-style-type: none"> <li>▪ Molecules and atoms from the environment are necessary to build new molecules.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Cohesion</li> <li>▪ Adhesion</li> <li>▪ Specific Heat Capacity</li> <li>▪ Heat of fusion</li> <li>▪ Water’s thermal conductivity</li> </ul>	<ul style="list-style-type: none"> <li>▪ Carbon moves from the environment to organisms where it is used to build carbohydrates, proteins, lipids, or nucleic acids. Carbon is used in storage compounds and cell formation in all organisms.</li> <li>▪ Nitrogen moves from the environment to organisms where it is used in building proteins and nucleic acids. Phosphorus moves from the environment to organisms where it is used in nucleic acids and certain lipids.</li> <li>▪ Living systems depend on properties of water that result from its polarity and hydrogen bonding.</li> </ul>
<p><b>Essential knowledge:</b> The subcomponents of biological molecules and their sequence determine the properties of that</p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Bonding</li> <li>▪ DNA and RNA building</li> <li>▪ Protein building activity</li> </ul>	<ul style="list-style-type: none"> <li>▪ In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate and a nitrogen base (adenine, thymine, guanine,</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 1: ENERGY TRANSFER/WATER/MACROMOLECULES**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>molecule. <b>(4.A.1)</b></p> <ul style="list-style-type: none"> <li>▪ Structure and function of polymers are derived from the way their monomers are assembled.</li> <li>▪ Directionality influences structure and function of the polymer.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Phospholipid bilayer modeling</li> </ul>	<p>cytosine or uracil). DNA and RNA differ in function and differ slightly in structure, and these structural differences account for the differing functions.</p> <ul style="list-style-type: none"> <li>▪ In proteins, the specific order of amino acids in a polypeptide (primary structure) interacts with the environment to determine the overall shape of the protein, which also involves secondary tertiary and quaternary structure and, thus, its function. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic and ionic), and the interactions of these R groups determine structure and function of that region of the protein.</li> <li>▪ In general, lipids are nonpolar; however, phospholipids exhibit structural properties, with polar regions that interact with other polar molecules such as water, and with nonpolar regions where differences in saturation determine the structure and function of lipids.</li> <li>▪ Carbohydrates are composed of sugar monomers whose structures and bonding with each other by dehydration synthesis determine the properties and functions of the molecules. Illustrative examples include: cellulose versus starch.</li> <li>▪ Proteins have an amino (NH<sub>2</sub>) end and a carboxyl (COOH) end, and consist of a linear sequence of amino acids connected by the formation of peptide bonds by dehydration synthesis between the amino and carboxyl groups of adjacent monomers.</li> </ul>
<p><b>Essential knowledge:</b> Interactions between molecules affect their structure and function. <b>(4.B.1)</b></p> <ul style="list-style-type: none"> <li>▪ Change in the structure of a molecular system may result in a change of the function of the system.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Eppendorfase Enzyme Activity</li> <li>▪ pH and temperatures effect on the rate of an enzymatic reaction</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> </ul>	<ul style="list-style-type: none"> <li>▪ For an enzyme-mediated chemical reaction to occur, the substrate must be complementary to the surface properties (shape and charge) of the active site. In other words, the substrate must fit into the enzyme's active site.</li> <li>▪ Cofactors and coenzymes affect enzyme function; this interaction relates to a structural change that alters the activity rate of the enzyme. The enzyme may only become active when</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 1: ENERGY TRANSFER/WATER/MACROMOLECULES**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme.</li> <li>▪ Other molecules and the environment in which the enzyme acts can enhance or inhibit enzyme activity. Molecules can bind reversibly or irreversibly to the active or allosteric sites, changing the activity of the enzyme.</li> <li>▪ The change in function of an enzyme can be interpreted from data regarding the concentrations of product or substrate as a function of time. These representations demonstrate the relationship between an enzyme’s activity, the disappearance of substrate, and/or presence of a competitive inhibitor.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<p>all the appropriate cofactors or coenzymes are present and bind to the appropriate sites on the enzyme.</p>

**UCONN ECE BIOLOGY**  
**UNIT 2: CELLS, CELL COMMUNICATION AND SIGNALING**

**Objectives:** Big Ideas 2, 3 and 4

**Enduring understanding 2.A:** Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

**Enduring understanding 2.B:** Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments

**Enduring understanding 2.E:** Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

**Enduring understanding 3.B:** Expression of genetic information involves cellular and molecular mechanisms

**Enduring understanding 3.D:** Cells communicate by generating, transmitting and receiving chemical signals.

**Enduring understanding 4.A:** Interactions within biological systems lead to complex properties.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> Organisms must exchange matter with the environment to grow, reproduce and maintain organization. <b>(2.A.3)</b></p> <ul style="list-style-type: none"> <li>▪ Surface area-to-volume ratios affect a biological system’s ability to obtain necessary resources or eliminate waste products.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Root Hairs</li> <li>▪ Cells of the alveoli</li> <li>▪ Cells of the villi</li> <li>▪ Microvilli</li> </ul>	<ul style="list-style-type: none"> <li>▪ As cells increase in volume, the relative surface area decreases and demand for material resources increases; more cellular structures are necessary to adequately exchange materials and energy with the environment. These limitations restrict cell size.</li> <li>▪ The surface area of the plasma membrane must be large enough to adequately exchange materials; smaller cells have a more favorable surface area-to-volume ratio for exchange of materials with the environment.</li> </ul>
<p><b>Essential knowledge:</b> Cell membranes are selectively permeable due to their structure. <b>(2.B.1)</b></p> <ul style="list-style-type: none"> <li>▪ Cell membranes separate the internal environment of the cell from the external environment.</li> <li>▪ Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.</li> <li>▪ Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal</li> </ul>	<ul style="list-style-type: none"> <li>▪ Protein building activity revisited with a look at protein folding and placement</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cell membranes consist of a structural framework of phospholipid molecules, embedded proteins, cholesterol, glycoproteins and glycolipids.</li> <li>▪ Phospholipids give the membrane both hydrophilic and hydrophobic properties. The hydrophilic phosphate portions of the phospholipids are oriented toward the aqueous external or internal environments, while the hydrophobic fatty acid portions face each other within the interior of the membrane itself.</li> <li>▪ Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.</li> <li>▪ Small, uncharged polar molecules and small nonpolar molecules, such as N<sub>2</sub>, freely pass across the membrane. Hydrophilic substances such as large polar molecules and ions move across the membrane through embedded channel and</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 2: CELLS, CELL COMMUNICATION AND SIGNALING**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
environments.		<p>transport proteins. Water moves across membranes and through channel proteins called aquaporins.</p> <ul style="list-style-type: none"> <li>▪ Plant cell walls are made of cellulose and are external to the cell membrane.</li> <li>▪ Other examples are cells walls of prokaryotes and fungi.</li> </ul>
<p><b>Essential knowledge:</b> Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes. <b>(2.B.2)</b></p> <ul style="list-style-type: none"> <li>▪ Passive transport does not require the input of metabolic energy; the net movement of molecules is from high concentration to low concentration.</li> <li>▪ Active transport requires free energy to move molecules from regions of low concentration to regions of high concentration.</li> <li>▪ The processes of endocytosis and exocytosis move large molecules from the external environment to the internal environment and vice versa, respectively</li> </ul>	<ul style="list-style-type: none"> <li>▪ Passive Transport and Active Transport Lab</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Passive transport plays a primary role in the import of resources and the export of wastes.</li> <li>▪ Membrane proteins play a role in facilitated diffusion of charged and polar molecules through a membrane.</li> <li>▪ External environments can be hypotonic, hypertonic or isotonic to internal environments of cells.</li> <li>▪ Active transport is a process where free energy (often provided by ATP) is used by proteins embedded in the membrane to “move” molecules and/or ions across the membrane and to establish and maintain concentration gradients.</li> <li>▪ Membrane proteins are necessary for active transport.</li> <li>▪ In exocytosis, internal vesicles fuse with the plasma membrane to secrete large macromolecules out of the cell.</li> <li>▪ In endocytosis, the cell takes in macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.</li> </ul>
<p><b>Essential knowledge:</b> Timing and coordination of physiological events are regulated by multiple mechanisms. <b>(2.E.2)</b></p>	<p>Illustrative Examples:</p> <ul style="list-style-type: none"> <li>▪ Circadian Rhythms</li> <li>▪ Jet Lag in Humans</li> <li>▪ Seasonal Response</li> <li>▪ Release and reaction to pheromones</li> <li>▪ Visual displays in the reproductive cycles</li> </ul>	<ul style="list-style-type: none"> <li>▪ In fungi, protists and bacteria, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.</li> </ul>



**UConn ECE BIOLOGY**  
**UNIT 2: CELLS, CELL COMMUNICATION AND SIGNALING**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> A variety of intercellular and intracellular signal transmissions mediate gene expression. <b>(3.B.2)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Cytokinesis</li> <li>▪ Yeast Mating signals</li> <li>▪ P53 gene changes and cancer</li> </ul>	<ul style="list-style-type: none"> <li>▪ Signal transmission within and between cells mediates gene expression.</li> <li>▪ Signal transmission within and between cells mediates cell function.</li> </ul>
<p><b>Essential knowledge:</b> Cell communication processes share common features that reflect a shared evolutionary history. <b>(3.D.1)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Hormone Signaling</li> <li>▪ DNA repair</li> </ul>	<ul style="list-style-type: none"> <li>▪ Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment.</li> <li>▪ Correct and appropriate signal transduction processes are generally under strong selective pressure.</li> <li>▪ In single-celled organisms, signal transduction pathways influence how the cell responds to its environment.</li> <li>▪ In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.</li> </ul>
<p><b>Essential knowledge:</b> Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. <b>(3.D.2)</b></p> <ul style="list-style-type: none"> <li>▪ Cells communicate by cell-to-cell contact.</li> <li>▪ Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell.</li> <li>▪ Signals released by one cell type can travel long distances to target cells of another cell type.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Neurotransmitters</li> <li>▪ Insulin</li> <li>▪ Human Growth Hormone</li> </ul>	<ul style="list-style-type: none"> <li>▪ Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body.</li> </ul>
<p><b>Essential knowledge:</b> Signal transduction pathways link signal reception with cellular response. <b>(3.D.3)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ G-Protein pathways</li> <li>▪ Cell communication presentations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Different receptors recognize different chemical messengers, which can be peptides, small chemicals or proteins, in a specific one-to-one relationship.</li> <li>▪ A receptor protein recognizes signal molecules, causing the</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 2: CELLS, CELL COMMUNICATION AND SIGNALING**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Signaling begins with the recognition of a chemical messenger, a ligand, by a receptor protein.</li> <li>▪ Signal transduction is the process by which a signal is converted to a cellular response.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Tyrosine Kinases</li> <li>▪ AP Short answer questions</li> </ul>	<p>receptor protein’s shape to change, which initiates transduction of the signal.</p> <ul style="list-style-type: none"> <li>▪ Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, with the result of appropriate responses by the cell.</li> <li>▪ Second messengers are often essential to the function of the cascade.</li> <li>▪ Many signal transduction pathways include:</li> <li>▪ Protein modifications (an illustrative example could be how methylation changes the signaling process)</li> <li>▪ Phosphorylation cascades in which a series of protein kinases add a phosphate group to the next protein in the cascade sequence.</li> </ul>
<p><b>Essential knowledge:</b> The structure and function of subcellular components, and their interactions, provide essential cellular processes. <b>(4.A.2)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Cell diagrams</li> <li>▪ Cell inactive websites</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ribosomes are small, universal structures comprised of two interacting parts: ribosomal RNA and protein. In a sequential manner, these cellular components interact to become the site of protein synthesis where the translation of the genetic instructions yields specific polypeptides.</li> <li>▪ Endoplasmic reticulum (ER) occurs in two forms: smooth and rough.</li> <li>▪ The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs (cisternae).</li> <li>▪ Mitochondria specialize in energy capture and transformation.</li> <li>▪ Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell’s organic materials and programmed cell death (apoptosis). Lysosomes carry out intracellular digestion in a variety of ways.</li> <li>▪ A vacuole is a membrane-bound sac that plays roles in intracellular digestion and the release of cellular waste products. In plants, a large vacuole serves many functions, from storage of pigments or poisonous substances to a role in cell growth. In addition, a large central vacuole allows for a</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 2: CELLS, CELL COMMUNICATION AND SIGNALING**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<p>large surface area to volume ratio.</p> <ul style="list-style-type: none"> <li>▪ Chloroplasts are specialized organelles found in algae and higher plants that capture energy through photosynthesis.</li> </ul>
<p><b>Essential knowledge:</b> Cooperative interactions within organisms promote efficiency in the use of energy and matter. <b>(4.B.2)</b></p> <ul style="list-style-type: none"> <li>▪ Organisms have areas or compartments that perform a subset of functions related to energy and matter, and these parts contribute to the whole.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Cellular Respiration</li> <li>▪ Photosynthesis</li> </ul>	<ul style="list-style-type: none"> <li>▪ At the cellular level, the plasma membrane, cytoplasm and, for eukaryotes, the organelles contribute to the overall specialization and functioning of the cell.</li> <li>▪ Interactions among cells of a population of unicellular organisms can be similar to those of multicellular organisms, and these interactions lead to increased efficiency and utilization of energy and matter.</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 3: CELLULAR RESPIRATION AND PHOTOSYNTHESIS**

**Objectives** Big Idea 2

**Enduring understanding 2.A:** Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> All living systems require constant input of free energy. <b>(2.A.1)</b></p> <ul style="list-style-type: none"> <li>▪ Life requires a highly ordered system.</li> <li>▪ Living systems do not violate the second law of thermodynamics, which states that entropy increases over time.</li> <li>▪ Energy-related pathways in biological systems are sequential and may be entered at multiple points in the pathway.</li> <li>▪ Organisms use free energy to maintain organization, grow and reproduce.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Enzyme Kinetics</li> <li>▪ Cellular Respiration</li> <li>▪ Photosynthesis</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased disorder and entropy are offset by biological processes that maintain or increase order.</li> <li>▪ Reproduction and rearing of offspring require free energy beyond that used for maintenance and growth. Different organisms use various reproductive strategies in response to energy availability.</li> <li>▪ There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms — generally, the smaller the organism, the higher the metabolic rate.</li> <li>▪ Excess acquired free energy versus required free energy expenditure results in energy storage or growth.</li> <li>▪ Insufficient acquired free energy versus required free energy expenditure results in loss of mass and, ultimately, the death of an organism.</li> </ul>
<p><b>Essential knowledge:</b> Organisms capture and store free energy for use in biological processes. <b>(2.A.2)</b></p> <ul style="list-style-type: none"> <li>▪ Autotrophs capture free energy from physical sources in the environment.</li> <li>▪ Heterotrophs capture free energy present in carbon compounds produced by other organisms.</li> <li>▪ Different energy-capturing processes use different types of electron acceptors.</li> <li>▪ The light-dependent reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Photosynthetic Maps</li> <li>▪ Light Reaction Maps</li> <li>▪ Animations and videos demonstrating electron transport chain</li> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> </ul>	<ul style="list-style-type: none"> <li>▪ Photosynthetic organisms capture free energy present in sunlight.</li> <li>▪ During photosynthesis, chlorophylls absorb free energy from light, boosting electrons to a higher energy level in Photosystems I and II.</li> <li>▪ Photosystems I and II are embedded in the internal membranes of chloroplasts (thylakoids) and are connected by the transfer of higher free energy electrons through an electron transport chain (ETC).</li> <li>▪ The formation of the proton gradient is a separate process, but it is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase.</li> <li>▪ The energy captured in the light reactions as ATP and NADPH powers the production of carbohydrates from</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 3: CELLULAR RESPIRATION AND PHOTOSYNTHESIS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>that capture free energy present in light to yield ATP and NADPH, which power the production of organic molecules.</p> <ul style="list-style-type: none"> <li>▪ Photosynthesis first evolved in prokaryotic organisms; scientific evidence supports that prokaryotic (bacterial) photosynthesis was responsible for the production of an oxygenated atmosphere; prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.</li> <li>▪ Cellular respiration in eukaryotes involves a series of coordinated enzyme catalyzed reactions that harvest free energy from simple carbohydrates.</li> <li>▪ The electron transport chain captures free energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes.</li> <li>▪ Free energy becomes available for metabolism by the conversion of ATP→ADP, which is coupled to many steps in metabolic pathways.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<p>carbon dioxide in the Calvin cycle, which occurs in the stroma of the chloroplast.</p> <ul style="list-style-type: none"> <li>▪ Glycolysis rearranges the bonds in glucose molecules, releasing free energy to form ATP from ADP and inorganic phosphate, and resulting in the production of pyruvate.</li> <li>▪ In the Krebs cycle, carbon dioxide is released from organic intermediates ATP is synthesized from ADP and inorganic phosphate via substrate level phosphorylation and electrons are captured by coenzymes.</li> <li>▪ Electron transport chain reactions occur in chloroplasts (photosynthesis), mitochondria (cellular respiration) and prokaryotic plasma membranes.</li> <li>▪ The passage of electrons is accompanied by the formation of a proton gradient across the inner mitochondrial membrane or the thylakoid membrane of chloroplasts, with the membrane(s) separating a region of high proton concentration from a region of low proton concentration.</li> </ul>

## UCONN ECE BIOLOGY UNIT 4: MITOSIS AND MEIOSIS

**Objectives :** Big Ideas: 3 and 4

**Enduring understanding 3.A:** Heritable information provides for continuity of life.

**Enduring understanding 3.C:** The processing of genetic information is imperfect and is a source of genetic variation.

**Enduring understanding 4.C:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization. <b>(3.A.2)</b></p> <ul style="list-style-type: none"> <li>▪ The cell cycle is a complex set of stages that is highly regulated with checkpoints, which determine the ultimate fate of the cell.</li> <li>▪ Mitosis passes a complete genome from the parent cell to daughter cells.</li> <li>▪ Meiosis, a reduction division, followed by fertilization ensures genetic diversity in sexually reproducing organisms.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Mitosis Promoting Factor</li> <li>▪ Cancer</li> <li>▪ Mitosis Lab</li> <li>▪ Meiosis Sodaria Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The cell cycle is directed by internal controls or checkpoints. Internal and external signals provide stop-and-go signs at the checkpoints.</li> <li>▪ Cyclins and cyclin-dependent kinases control the cell cycle.</li> <li>▪ Mitosis occurs after DNA replication.</li> <li>▪ Mitosis plays a role in growth, repair, and asexual reproduction.</li> <li>▪ Mitosis is a continuous process with observable structural features along the mitotic process. Evidence of student learning is demonstrated by knowing the order of the processes (replication, alignment, separation).</li> <li>▪ Meiosis ensures that each gamete receives one complete haploid (1n) set of chromosomes.</li> <li>▪ During meiosis, homologous chromosomes are paired, with one homologue originating from the maternal parent and the other from the paternal parent.</li> <li>▪ During meiosis, homologous chromatids exchange genetic material via a process called “crossing over,” which increases genetic variation in the resultant gametes.</li> <li>▪ Fertilization involves the fusion of two gametes, increases genetic variation in populations by providing for new combinations of genetic information in the zygote, and restores the diploid number of chromosomes.</li> </ul>
<p><b>Essential knowledge:</b> The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of</p>	<ul style="list-style-type: none"> <li>▪ Sodaria Crossing over Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ Segregation and independent assortment can be applied to genes that are on different chromosomes.</li> <li>▪ Genes that are adjacent and close to each other on the same chromosome tend to move as a unit; the probability</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 4: MITOSIS AND MEIOSIS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>genes from parent to offspring. <b>(3.A.3)</b></p> <ul style="list-style-type: none"> <li>▪ Segregation and independent assortment of chromosomes result in genetic variation.</li> <li>▪ Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction.</li> <li>▪ Many ethical, social and medical issues surround human genetic disorders.</li> </ul>		<p>that they will segregate as a unit is a function of the distance between them.</p>
<p><b>Essential knowledge:</b> Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts. <b>(3.C.3)</b></p> <ul style="list-style-type: none"> <li>▪ Viral replication differs from other reproductive strategies and generates genetic variation via various mechanisms.</li> <li>▪ The reproductive cycles of viruses facilitate transfer of genetic information.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Transduction in bacteria</li> </ul>	<ul style="list-style-type: none"> <li>▪ Viruses have highly efficient replicative capabilities that allow for rapid evolution and acquisition of new phenotypes.</li> <li>▪ Viruses replicate via a component assembly model allowing one virus to produce many progeny simultaneously via the lytic cycle.</li> <li>▪ RNA viruses lack replication error-checking mechanisms, and thus have higher rates of mutation.</li> <li>▪ Viruses transmit DNA or RNA when they infect a host cell.</li> <li>▪ Some viruses are able to integrate into the host DNA and establish a latent (lysogenic) infection. These latent viral genomes can result in new properties for the host such as increased pathogenicity in bacteria.</li> </ul>
<p><b>Essential knowledge:</b> The level of variation in a population affects population dynamics. <b>(4.C.3)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ California Condors</li> <li>▪ Black-footed Ferrets</li> <li>▪ Corn Rust and agriculture</li> <li>▪ Disease outbreak in populations</li> <li>▪ Quizzes</li> </ul>	<ul style="list-style-type: none"> <li>▪ Population ability to respond to changes in the environment is affected by genetic diversity. Species and populations with little genetic diversity are at risk for extinction.</li> <li>▪ Genetic diversity allows individuals in a population to respond differently to the same changes in environmental conditions.</li> <li>▪ Allelic variation within a population can be modeled by the</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 4: MITOSIS AND MEIOSIS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
	<ul style="list-style-type: none"> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<p>Hardy-Weinberg equation(s).</p>



## UCONN ECE BIOLOGY UNIT 5: DNA AND GENETICS

**Objectives** Big Ideas: 2, 3 and 4

**Enduring understanding 2.E:** Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

**Enduring understanding 3.A:** Heritable information provides for continuity of life.

**Enduring understanding 3.B:** Expression of genetic information involves cellular and molecular mechanisms

**Enduring understanding 3.C:** The processing of genetic information is imperfect and is a source of genetic variation.

**Enduring understanding 4.A:** Interactions within biological systems lead to complex properties.

**Enduring understanding 4.C:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> DNA, and in some cases RNA, is the primary source of heritable information. <b>(3.A.1)</b></p> <ul style="list-style-type: none"> <li>▪ Genetic information is transmitted from one generation to the next through DNA or RNA.</li> <li>▪ DNA and RNA molecules have structural similarities and differences that define function.</li> <li>▪ Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein.</li> <li>▪ Phenotypes are determined through protein activities.</li> <li>▪ Genetic engineering techniques can manipulate the heritable information of DNA and, in special cases, RNA.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ PCR- Polymerase Chain Reaction</li> <li>▪ Restriction Enzyme Analysis</li> <li>▪ Cloning</li> <li>▪ Pharmaceuticals</li> </ul>	<ul style="list-style-type: none"> <li>▪ Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules.</li> <li>▪ Prokaryotes, viruses and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded circular DNA molecules.</li> <li>▪ DNA replication ensures continuity of hereditary information.</li> <li>▪ Both have three components — sugar, phosphate and a nitrogenous base — which form nucleotide units that are connected by covalent bonds to form a linear molecule with 3' and 5' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.</li> <li>▪ Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G).</li> <li>▪ The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function.</li> <li>▪ The enzyme RNA-polymerase reads the DNA molecule in the 3' to 5' direction and synthesizes complementary mRNA molecules that determine the order of amino acids in the polypeptide.</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 5: DNA AND GENETICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>Changes in genotype can result in changes in phenotype. <b>(3.C.1)</b></p> <ul style="list-style-type: none"> <li>▪ Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype.</li> <li>▪ Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random changes, e.g., mutations in the DNA.</li> <li>▪ Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selection by environmental conditions</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Antibiotic resistance</li> <li>▪ Pesticide resistance</li> </ul>	<ul style="list-style-type: none"> <li>▪ In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications.</li> <li>▪ DNA mutations can be positive, negative or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein.</li> <li>▪ Whether or not a mutation is detrimental, beneficial or neutral depends on the environmental context. Mutations are the primary source of genetic variation.</li> <li>▪ Selection results in evolutionary change.</li> </ul>
<p><b>Essential knowledge:</b> Variation in molecular units provides cells with a wider range of function. <b>(4.C.1)</b></p> <ul style="list-style-type: none"> <li>▪ Multiple copies of alleles or genes (gene duplication) may provide new phenotypes.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Antibiotic resistance</li> <li>▪ Pesticide resistance</li> <li>▪ Sickle Cell disorder and the heterozygote advantage</li> </ul>	<ul style="list-style-type: none"> <li>▪ A heterozygote may be a more advantageous genotype than a homozygote under particular conditions, since with two different alleles, the organism has two forms of proteins that may provide functional resilience in response to environmental stresses.</li> <li>▪ Gene duplication creates a situation in which one copy of the gene maintains its original function, while the duplicate may evolve a new function.</li> </ul>
<p><b>Essential knowledge:</b> The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. <b>(3.A.3)</b></p> <ul style="list-style-type: none"> <li>▪ Rules of probability can be applied to analyze passage of single gene traits from parent to offspring.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Genetic Disorders</li> </ul>	<ul style="list-style-type: none"> <li>▪ Segregation and independent assortment can be applied to genes that are on different chromosomes.</li> <li>▪ Genes that are adjacent and close to each other on the same chromosome tend to move as a unit; the probability that they will segregate as a unit is a function of the distance between them.</li> <li>▪ The pattern of inheritance (monohybrid, dihybrid, sex-</li> </ul>

**UConn ECE BIOLOGY  
UNIT 5: DNA AND GENETICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Segregation and independent assortment of chromosomes result in genetic variation.</li> <li>▪ Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction.</li> <li>▪ Many ethical, social and medical issues surround human genetic disorders</li> </ul>		<p>linked, and genes linked on the same homologous chromosome) can often be predicted from data that gives the parent genotype/phenotype and/or the offspring phenotypes/genotypes.</p>
<p><b>Essential knowledge:</b> The inheritance pattern of many traits cannot be explained by simple Mendelian genetics. <b>(3.A.4)</b></p> <ul style="list-style-type: none"> <li>▪ Many traits are the product of multiple genes and/or physiological processes.</li> <li>▪ Some traits are determined by genes on sex chromosomes.</li> <li>▪ Some traits result from nonnuclear inheritance.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Animations and online genetics manipulations</li> <li>▪ Genetics Word Problems</li> </ul>	<ul style="list-style-type: none"> <li>▪ Patterns of inheritance of many traits do not follow ratios predicted by Mendel’s laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios.</li> <li>▪ Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules.</li> <li>▪ In animals, mitochondrial DNA is transmitted by the egg and not by sperm; as such, mitochondrial-determined traits are maternally inherited</li> </ul>
<p><b>Essential knowledge:</b> Changes in genotype can result in changes in phenotype. <b>(3.C.1)</b></p> <ul style="list-style-type: none"> <li>▪ Errors in mitosis or meiosis can result in changes in phenotype.</li> </ul>	<p>Illustrative Examples of :</p> <ul style="list-style-type: none"> <li>▪ The Lac Operon</li> <li>▪ The Tryp Operon</li> </ul>	<ul style="list-style-type: none"> <li>▪ Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy and increased vigor of other polyploids.</li> <li>▪ Changes in chromosome number often result in human disorders with developmental limitations, including Trisomy 21 (Down syndrome) and XO (Turner syndrome).</li> </ul>
<p><b>Essential knowledge:</b> Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms. <b>(2.E.1)</b></p> <ul style="list-style-type: none"> <li>▪ Observable cell differentiation results from the expression of genes for tissue-</li> </ul>		<ul style="list-style-type: none"> <li>▪ Homeotic genes are involved in developmental patterns and sequences.</li> <li>▪ Embryonic induction in development results in the correct timing of events.</li> <li>▪ Temperature and the availability of water determine seed germination in most plants.</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 5: DNA AND GENETICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>specific proteins.</p> <ul style="list-style-type: none"> <li>▪ Induction of transcription factors during development results in sequential gene expression.</li> <li>▪ Programmed cell death (apoptosis) plays a role in the normal development</li> </ul>		
<p><b>Essential knowledge:</b> Gene regulation results in differential gene expression, leading to cell specialization. <b>(3.B.1)</b></p> <ul style="list-style-type: none"> <li>▪ Both DNA regulatory sequences, regulatory genes, and small regulatory RNAs are involved in gene expression.</li> <li>▪ Both positive and negative control mechanisms regulate gene expression in bacteria and viruses.</li> <li>▪ In eukaryotes, gene expression is complex and control involves regulatory genes, regulatory elements and transcription factors that act in concert.</li> <li>▪ Gene regulation accounts for some of the phenotypic differences between organisms with similar genes.</li> </ul>		<ul style="list-style-type: none"> <li>▪ Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription.</li> <li>▪ The expression of specific genes can be turned on by the presence of an inducer.</li> <li>▪ The expression of specific genes can be inhibited by the presence of a repressor.</li> <li>▪ Inducers and repressors are small molecules that interact with regulatory proteins and/or regulatory sequences.</li> <li>▪ Regulatory proteins stimulate gene expression by binding to DNA and stimulating transcription (positive control) or binding to repressors to inactivate repressor function.</li> <li>▪ Certain genes are continuously expressed; that is, they are always turned “on,” e.g., the ribosomal genes</li> </ul>
<p><b>Essential knowledge:</b> Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs. <b>(4.A.3)</b></p>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group</li> </ul>	<ul style="list-style-type: none"> <li>▪ Differentiation in development is due to external and internal cues that trigger gene regulation by proteins that bind to DNA.</li> <li>▪ Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type.</li> <li>▪ Environmental stimuli can affect gene expression in a mature cell.</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 5: DNA AND GENETICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
	activities <ul style="list-style-type: none"><li>▪ Collaborative group presentations</li><li>▪ Peer teaching</li><li>▪ Simulation activities</li><li>▪ Videos and films</li></ul>	

**UCONN ECE BIOLOGY  
UNIT 6: EVOLUTION**

**Objectives: Big Ideas: 1**

**Essential Questions** (that go with the objectives)

**Enduring Understanding 1.A:** Change in the **genetic makeup of a population** over time is evolution.

**Enduring Understanding 1.B:** Organisms are linked by lines of descent from common ancestry.

**Enduring understanding 1.C:** Life continues to evolve within a changing environment.

**Enduring understanding 1.D:** The origin of living systems is explained by natural processes.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> Natural selection is a major mechanism of evolution. <b>(1.A.1)</b></p>	<ul style="list-style-type: none"> <li>▪ Graphical analysis of allelic frequencies in a population</li> <li>▪ Hardy-Weinberg equilibrium</li> </ul>	<ul style="list-style-type: none"> <li>▪ According to Darwin’s theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.</li> <li>▪ Evolutionary fitness is measured by reproductive success.</li> <li>▪ Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.</li> <li>▪ Environments can be more or less stable or fluctuating, and this affects evolutionary rate and direction; different genetic variations can be selected in each generation.</li> <li>▪ An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.</li> <li>▪ In addition to natural selection, chance and random events can influence the evolutionary process, especially for small populations.</li> <li>▪ Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are: (1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating and (5) absence of selection. These conditions are seldom met.</li> <li>▪ Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population.</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 6: EVOLUTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> Natural selection acts on phenotypic variations in populations. <b>(1.A.2)</b></p>	<ul style="list-style-type: none"> <li>▪ Flowering time in relation to global climate change</li> <li>▪ Peppered Moth Activity</li> <li>▪ Population Genetics Activity</li> <li>▪ Pollenpeeper Activity</li> </ul>	<ul style="list-style-type: none"> <li>▪ Environments change and act as selective mechanism on populations.</li> <li>▪ Phenotypic variations are not directed by the environment but occur through random changes in the DNA and through new gene combinations.</li> <li>▪ Some phenotypic variations significantly increase or decrease fitness of the organism and the population.</li> <li>▪ Humans impact variation in other species.</li> </ul>
<p><b>Essential knowledge:</b> Evolutionary change is also driven by random processes. <b>(1.A.3)</b></p>		<ul style="list-style-type: none"> <li>▪ Genetic drift is a nonselective process occurring in small populations.</li> <li>▪ Reduction of genetic variation within a given population can increase the differences between populations of the same species.</li> </ul>
<p><b>Essential knowledge:</b> Biological evolution is supported by scientific evidence from many disciplines, including mathematics. <b>(1.A.4)</b></p> <ul style="list-style-type: none"> <li>▪ Scientific evidence of biological evolution uses information from geographical, geological, physical, chemical and mathematical applications.</li> <li>▪ Molecular, morphological and genetic information of existing and extinct organisms add to our understanding of evolution.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Phylogeny</li> <li>▪ Cladistics</li> <li>▪ Creation of Cladograms</li> <li>▪ Genetic analysis and creations of phylogenetic trees</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fossils can be dated by a variety of methods that provide evidence for evolution. These include the age of the rocks where a fossil is found, the rate of decay of isotopes including carbon-14, the relationships within phylogenetic trees, and the mathematical calculations that take into account information from chemical properties and/or geographical data.</li> <li>▪ Morphological homologies represent features shared by common ancestry. Vestigial structures are remnants of functional structures, which can be compared to fossils and provide evidence for evolution.</li> <li>▪ Biochemical and genetic similarities, in particular DNA nucleotide and protein sequences, provide evidence for evolution and ancestry.</li> <li>▪ Mathematical models and simulations can be used to illustrate and support evolutionary concepts.</li> </ul>
<p><b>Essential knowledge:</b> Organisms share many conserved core</p>		<ul style="list-style-type: none"> <li>▪ DNA and RNA are carriers of genetic information through transcription, translation and replication.</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 6: EVOLUTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>processes and features that evolved and are widely distributed among organisms today. <b>(1.B.1)</b></p>		<ul style="list-style-type: none"> <li>▪ Major features of the genetic code are shared by all modern living systems.</li> <li>▪ Metabolic pathways are conserved across all currently recognized domains.</li> </ul>
<p><b>Essential knowledge:</b> Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested. <b>(1.B.2)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Phylogeny</li> <li>▪ Cladistics</li> <li>▪ Creation of Cladograms</li> <li>▪ Genetic analysis and creations of phylogenetic trees</li> </ul>	<ul style="list-style-type: none"> <li>▪ Phylogenetic trees and cladograms can represent traits that are either derived or lost due to evolution.</li> <li>▪ Phylogenetic trees and cladograms illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor.</li> <li>▪ Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species, and from DNA and protein sequence similarities, by employing computer programs that have sophisticated ways of measuring and representing relatedness among organisms.</li> <li>▪ Phylogenetic trees and cladograms are dynamic (i.e., phylogenetic trees and cladograms are constantly being revised), based on the biological data used, new mathematical and computational ideas, and current and emerging knowledge.</li> </ul>
<p><b>Essential knowledge:</b> Speciation and extinction have occurred throughout the Earth’s history. <b>(1.C.1)</b></p>		<ul style="list-style-type: none"> <li>▪ Speciation rates can vary, especially when adaptive radiation occurs when new habitats become available.</li> <li>▪ Species extinction rates are rapid at times of ecological stress.</li> </ul>
<p><b>Essential knowledge:</b> Speciation may occur when two populations become reproductively isolated from each other. <b>(1.C.2)</b></p>		<ul style="list-style-type: none"> <li>▪ Speciation results in diversity of life forms. Species can be physically separated by a geographic barrier such as an ocean or a mountain range, or various pre- and post-zygotic mechanisms can maintain reproductive isolation and prevent gene flow.</li> </ul>



**UCONN ECE BIOLOGY  
UNIT 6: EVOLUTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<ul style="list-style-type: none"> <li>▪ New species arise from reproductive isolation over time, which can involve scales of hundreds of thousands or even millions of years, or speciation can occur rapidly through mechanisms such as polyploidy in plants.</li> </ul>
<p><b>Essential knowledge:</b> Populations of organisms continue to evolve. <b>(1.C.3)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Emergent Diseases</li> <li>▪ Chemical Resistance</li> <li>▪ Darwin’s Finches</li> </ul>	<ul style="list-style-type: none"> <li>▪ Scientific evidence supports the idea that evolution has occurred in all species.</li> <li>▪ Scientific evidence supports the idea that evolution continues to occur.</li> </ul>
<p><b>Essential knowledge:</b> There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence. <b>(1.D.1)</b></p>		<ul style="list-style-type: none"> <li>▪ Scientific evidence supports the various models.</li> </ul>
<p><b>Essential knowledge:</b> Scientific evidence from many different disciplines supports models of the origin of life. <b>(1.D.2)</b></p>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<ul style="list-style-type: none"> <li>▪ Geological evidence provides support for models of the origin of life on Earth.</li> <li>▪ Molecular and genetic evidence from extant and extinct organisms indicates that all organisms on Earth share a common ancestral origin of life.</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 7: ANIMAL FORM AND FUNCTION**

**Big Ideas 2, 3 and 4**

**Enduring understanding 2.B:** Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments

**Enduring understanding 2.C:** Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.

**Enduring understanding 2.D:** Growth and dynamic homeostasis of a biological system are influenced by changes in the system’s environment.

**Enduring understanding 3.D:** Cells communicate by generating, transmitting and receiving chemical signals.

**Enduring understanding 3.E:** Transmission of information results in changes within and between biological systems

**Enduring understanding 4.A:** Interactions within biological systems lead to complex properties.

**Enduring understanding 4.B:** Competition and cooperation are important aspects of biological systems.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes. <b>(2.C.1)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Operons</li> <li>▪ Temperature regulation in animals</li> <li>▪ Plant responses in stress</li> <li>▪ Negative Feedback mechanism</li> <li>▪ Diabetes Type 1</li> <li>▪ Blood Clotting</li> </ul>	<ul style="list-style-type: none"> <li>▪ Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.</li> <li>▪ Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set-point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.</li> <li>▪ Alteration in the mechanisms of feedback often results in deleterious consequences.</li> </ul>
<p><b>Essential knowledge:</b> Organisms respond to changes in their external environments. <b>(2.C.2)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Phototropism</li> <li>▪ Hibernation</li> <li>▪ Taxis and Kineses</li> <li>▪ Circadian Rhythms</li> <li>▪ Shivering vs. Sweating in Humans</li> </ul>	<ul style="list-style-type: none"> <li>▪ Organisms respond to changes in their environment through behavioral and physiological mechanisms.</li> </ul>
<p><b>Essential knowledge:</b> Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.</p>		<ul style="list-style-type: none"> <li>▪ Continuity of homeostatic mechanisms reflects common ancestry, while changes may occur in response to different environmental conditions.</li> <li>▪ Organisms have various mechanisms for obtaining</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 7: ANIMAL FORM AND FUNCTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<b>(2.D.2)</b>		nutrients and eliminating wastes. <ul style="list-style-type: none"> <li>▪ Homeostatic control systems in species of microbes, plants and animals support common</li> </ul>
<b>Essential knowledge:</b> Biological systems are affected by disruptions to their dynamic homeostasis. <b>(2.D.3)</b>	Illustrative Examples of: <ul style="list-style-type: none"> <li>▪ Toxins</li> <li>▪ Dehydration</li> <li>▪ Pathogens</li> <li>▪ Salination</li> <li>▪ Hurricane impact</li> <li>▪ Human Impact</li> </ul>	<ul style="list-style-type: none"> <li>▪ Disruptions at the molecular and cellular levels affect the health of the organism.</li> </ul>
<b>Essential knowledge:</b> Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. <b>(2.D.4)</b>	<ul style="list-style-type: none"> <li>▪ Immune System Project</li> <li>▪ Auto immune disorders</li> </ul>	<ul style="list-style-type: none"> <li>▪ Plants, invertebrates and vertebrates have multiple, nonspecific immune responses.</li> <li>▪ Mammals use specific immune responses triggered by natural or artificial agents that disrupt dynamic homeostasis.</li> <li>▪ The mammalian immune system includes two types of specific responses: cell mediated and humoral.</li> <li>▪ In the cell-mediated response, cytotoxic T cells, a type of lymphocytic white blood cell, “target” intracellular pathogens when antigens are displayed on the outside of the cells.</li> <li>▪ In the humoral response, B cells, a type of lymphocytic white blood cell, produce antibodies against specific antigens.</li> <li>▪ Antigens are recognized by antibodies to the antigen.</li> <li>▪ Antibodies are proteins produced by B cells, and each antibody is specific to a particular antigen</li> <li>▪ A second exposure to an antigen results in a more rapid and enhanced immune response.</li> </ul>
<b>Essential knowledge:</b> Timing and coordination of physiological events are regulated by multiple mechanisms. <b>(2.E.2)</b>	Illustrative Examples of: <ul style="list-style-type: none"> <li>▪ Innate vs. Learned behaviors</li> <li>▪ Migrations</li> <li>▪ Courtship</li> </ul>	<ul style="list-style-type: none"> <li>▪ In plants, physiological events involve interactions between environmental stimuli and internal molecular signals.</li> <li>▪ In animals, internal and external signals regulate a variety of physiological responses that synchronize with</li> </ul>

**UCONN ECE BIOLOGY**  
**UNIT 7: ANIMAL FORM AND FUNCTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
	<ul style="list-style-type: none"> <li>▪ Fruiting body formation in Fungi</li> <li>▪ Niche and resource partitioning</li> </ul>	<p>environmental cycles and cues.</p> <ul style="list-style-type: none"> <li>▪ In fungi, protists and bacteria, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.</li> </ul>
<p><b>Essential knowledge:</b> Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection. <b>(2.E.3)</b></p> <ul style="list-style-type: none"> <li>▪ Responses to information and communication of information are vital to natural selection.</li> </ul>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Pollination</li> <li>▪ Plant hormones</li> <li>▪ Mutualistic Relationships</li> </ul>	<ul style="list-style-type: none"> <li>▪ In phototropism in plants, changes in the light source lead to differential growth, resulting in maximum exposure of leaves to light for photosynthesis.</li> <li>▪ In photoperiodism in plants, changes in the length of night regulate flowering and preparation for winter</li> <li>▪ Behaviors in animals are triggered by environmental cues and are vital to reproduction, natural selection and survival.</li> <li>▪ Cooperative behavior within or between populations contributes to the survival of the populations.</li> </ul>
<p><b>Essential knowledge:</b> Cell communication processes share common features that reflect a shared evolutionary history. <b>(3.D.1)</b></p>		<ul style="list-style-type: none"> <li>▪ Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment.</li> <li>▪ Correct and appropriate signal transduction processes are generally under strong selective pressure.</li> <li>▪ In single-celled organisms, signal transduction pathways influence how the cell responds to its environment.</li> <li>▪ In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.</li> </ul>
<p><b>Essential knowledge:</b> Organisms exhibit complex properties due to interactions between their constituent parts. <b>(4.A.4)</b></p>		<ul style="list-style-type: none"> <li>▪ Interactions and coordination between organs provide essential biological activities.</li> <li>▪ Interactions and coordination between systems provide essential biological activities.</li> </ul>
<p><b>Essential knowledge:</b> Cooperative interactions within organisms promote efficiency in the use of energy and matter. <b>(4.B.2)</b></p>	<ul style="list-style-type: none"> <li>▪ Quizzes</li> <li>▪ Unit test</li> <li>▪ Annotation</li> <li>▪ Cornell note-taking</li> </ul>	<ul style="list-style-type: none"> <li>▪ Within multicellular organisms, specialization of organs contributes to the overall functioning of the organism.</li> <li>▪ Interactions among cells of a population of unicellular organisms can be similar to those of multicellular</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 7: ANIMAL FORM AND FUNCTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
	<ul style="list-style-type: none"> <li>▪ Graphic organizer</li> <li>▪ Independent reading</li> <li>▪ Outlining/Note-taking</li> <li>▪ Picture notes</li> <li>▪ Class and small group discussion</li> <li>▪ Collaborative group activities</li> <li>▪ Collaborative group presentations</li> <li>▪ Peer teaching</li> <li>▪ Simulation activities</li> <li>▪ Videos and films</li> </ul>	<p>organisms, and these interactions lead to increased efficiency and utilization of energy and matter.</p>

## UCONN ECE BIOLOGY UNIT 8: ECOLOGY

### Big Ideas 2, 3, and 4

**Essential Questions** that go with the objectives)

**Enduring understanding 2.A:** Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

**Enduring understanding 2.D:** Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

**Enduring understanding 2.E:** Many biological processes involved in growth, reproduction and dynamic

**Enduring understanding 3.E:** Transmission of information results in changes within and between biological systems

**Enduring understanding 4.A:** Interactions within biological systems lead to complex properties.

**Enduring understanding 4.B:** Competition and cooperation are important aspects of biological systems.

**Enduring understanding 4.C:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<b>Essential knowledge:</b> All living systems require constant input of free energy. <b>(2.A.1)</b>		<ul style="list-style-type: none"> <li>▪ Changes in free energy availability can result in changes in population size.</li> <li>▪ Changes in free energy availability can result in disruptions to an ecosystem.</li> </ul>
<b>Essential knowledge:</b> All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy. <b>(2.D.1)</b>	Illustrative Examples of: <ul style="list-style-type: none"> <li>▪ Water availability</li> <li>▪ Food Chains and food webs</li> <li>▪ Species Diversity</li> <li>▪ Population Density</li> <li>▪ Algal Blooms</li> </ul>	<ul style="list-style-type: none"> <li>▪ Organism activities are affected by interactions with biotic and abiotic factors.</li> <li>▪ The stability of populations, communities and ecosystems is affected by interactions with biotic and abiotic factors.</li> </ul>
<b>Essential knowledge:</b> Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection. <b>(2.E.3)</b>	<ul style="list-style-type: none"> <li>▪ Learning occurs through interaction</li> </ul>	<ul style="list-style-type: none"> <li>▪ Individuals can act on information and communicate it to others.</li> <li>▪ Responses to information and communication of information are vital to natural selection.</li> <li>▪ Innate behaviors are behaviors that are inherited.</li> <li>▪ Learning occurs through interactions with the environment and other organisms.</li> <li>▪ Behaviors in animals are triggered by environmental cues and are vital to reproduction, natural selection and survival.</li> <li>▪ Cooperative behavior within or between populations contributes to the survival of the populations.</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 8: ECOLOGY**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p><b>Essential knowledge:</b> Individuals can act on information and communicate it to others. <b>(3.E.1)</b></p>		<ul style="list-style-type: none"> <li>▪ Organisms exchange information with each other in response to internal changes and external cues, which can change behavior.</li> <li>▪ Communication occurs through various mechanisms.</li> <li>▪ Responses to information and communication of information are vital to natural selection and evolution.</li> <li>▪ Living systems have a variety of signal behaviors or cues that produce changes in the behavior of other organisms and can result in differential reproductive success.</li> <li>▪ Animals use visual, audible, tactile, electrical and chemical signals to indicate dominance, find food, establish territory and ensure reproductive success.</li> <li>▪ Natural selection favors innate and learned behaviors that increase survival and reproductive fitness.</li> <li>▪ Cooperative behavior tends to increase the fitness of the individual and the survival of the population.</li> </ul>
<p><b>Essential knowledge:</b> Communities are composed of populations of organisms that interact in complex ways. <b>(4.A.5)</b></p>	<p>Illustrative Examples of:</p> <ul style="list-style-type: none"> <li>▪ Predator Prey Relationships</li> <li>▪ Symbiotic Relationships</li> <li>▪ Field Data</li> <li>▪ Global Climate change data</li> </ul>	<ul style="list-style-type: none"> <li>▪ The structure of a community is measured and described in terms of species composition and species diversity.</li> <li>▪ Mathematical or computer models are used to illustrate and investigate population interactions within and environmental impacts on a community.</li> <li>▪ Mathematical models and graphical representations are used to illustrate population growth patterns and interactions.</li> <li>▪ Reproduction without constraints results in the exponential growth of a population.</li> <li>▪ A population can produce a density of individuals that exceeds the system’s resource availability.</li> <li>▪ As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues.</li> <li>▪ Demographics data with respect to age distributions and fecundity can be used to study human populations.</li> </ul>
<p><b>Essential knowledge:</b> Interactions among living systems and with their</p>	<ul style="list-style-type: none"> <li>▪ Food Webs and Food Chains</li> </ul>	<ul style="list-style-type: none"> <li>▪ Energy flows, but matter is recycled.</li> <li>▪ Changes in regional and global climates and in atmospheric</li> </ul>

**UCONN ECE BIOLOGY  
UNIT 8: ECOLOGY**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>environment result in the movement of matter and energy. <b>(4.A.6)</b></p>		<p>composition influence patterns of primary productivity.</p> <ul style="list-style-type: none"> <li>▪ Organisms within food webs and food chains interact.</li> <li>▪ Food webs and food chains are dependent on primary productivity.</li> <li>▪ Human activities impact ecosystems on local, regional and global scales.</li> <li>▪ Many adaptations of organisms are related to obtaining and using energy and matter in a particular environment.</li> </ul>
<p><b>Essential knowledge:</b> Interactions between and within populations influence patterns of species distribution and abundance. <b>(4.B.3)</b></p>	<ul style="list-style-type: none"> <li>▪ Loss of a keystone species</li> <li>▪ Dutch Elm disease</li> </ul>	<ul style="list-style-type: none"> <li>▪ Interactions between populations affect the distributions and abundance of populations.</li> <li>▪ A population of organisms has properties that are different from those of the individuals that make up the population. The cooperation and competition between individuals contributes to these different properties.</li> <li>▪ Species-specific and environmental catastrophes, geological events, the sudden influx/depletion of abiotic resources or increased human activities affect species distribution and abundance.</li> <li>▪ Competition, parasitism, predation, mutualism and commensalism can affect population dynamics.</li> <li>▪ Relationships among interacting populations can be characterized by positive and negative effects, and can be modeled mathematically (predator/prey, epidemiological models, invasive species).</li> <li>▪ Many complex symbiotic relationships exist in an ecosystem, and feedback control systems play a role in the functioning of these ecosystems.</li> </ul>
<p><b>Essential knowledge:</b> Distribution of local and global ecosystems changes over time. <b>(4.B.4)</b></p>	<ul style="list-style-type: none"> <li>▪ El Nino</li> <li>▪ Continental Drift</li> </ul>	<ul style="list-style-type: none"> <li>▪ Human impact accelerates change at local and global levels.</li> <li>▪ Geological and meteorological events impact ecosystem distribution.</li> </ul>
<p><b>Essential knowledge:</b> The diversity of species within an ecosystem may influence the ability of the</p>	<ul style="list-style-type: none"> <li>▪ Height and weight in humans</li> <li>▪ Sex determination in reptiles</li> <li>▪ Darker fur color in cooler</li> </ul>	<ul style="list-style-type: none"> <li>▪ Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.</li> </ul>



**UCONN ECE BIOLOGY  
UNIT 8: ECOLOGY**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
ecosystem. <b>(4.C.4)</b>	regions <ul style="list-style-type: none"> <li>▪ Alteration in timing of flowering due to climate changes</li> </ul>	<ul style="list-style-type: none"> <li>▪ Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem. The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.</li> </ul>

**UCONN ECE BIOLOGY  
RESOURCES**

- Campbell, Neil and Reece, Jane B. 2008. AP Edition Biology, Eighth Edition, San Francisco, CA: Pearson Benjamin Cummings.
- MasteringBiology- online database from Pearson Benjamin Cummings 2015
- Campbell, Neil. Student AP Edition Biology Student Study Guide, Eighth Edition
- Biology Laboratory Manual, 8/e by Vodopich and Moore, 2008
- Principles of Biology 1 and 2 Laboratory Manual, Lombard, Karen. UCONN 2009
- Survival of the Sickest. Maolem, Sharone.
- The Immortal Life of Henrietta Lacks. Skloot, Rebecca.
- Laboratory/classroom combination that includes the space, facilities, and equipment to safely conduct hands-on inquiry-based investigations.
- Released multiple choice tests and Free Response biology questions from 1968 to present.
- Selected websites and electronic media
- AP Central

**UCONN ECE BIOLOGY  
PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>	<b>3<sup>rd</sup> Quarter</b>	<b>4<sup>th</sup> Quarter</b>
Unit 1: Energy Transfer / Water / Macromolecules	X			
Unit 2: Cells, Cell Communications and Signaling	X			
Unit 3: Cellular Respiration and Photosynthesis	X	>		
Unit 4: Mitosis and Meiosis		X		
Unit 5: DNA and Genetics			X	
Unit 6: Evolution			X	
Unit 7: Animal Form and Function			X	>
Unit 8: Ecology			X	>

## UCONN ECE BIOLOGY PACING GUIDE

Chapter	Title	Big Idea	Essential Knowledge
1	Introduction		
2	Chemical context of life		
3	Water	2	2a3
4	Carbon and molecular diversity	1, 2	1d1, 2a3
5	Structure and function of large biological molecules	3, 4	3a1, 4a1, 4b1, 4c1
6	Cell	2, 4	2a3, 2b3, 4a2, 4b2
7	Membrane	2	2b1, 2b2
8	Metabolism	2, 4	2a1, 4b1
9	Cellular respiration	2	2a1, 2a2
10	Photosynthesis	2	2a1, 2a2
11	Cell Communication	2, 3	2e2, 3b2, 3d1, 3d2, 3d3, 3d4
12	Mitosis	3	3a2
13	Meiosis	3	3a2, 3c2
14	Medal and the gen idea	3, 4	3a3, 4c2, 4c4
15	Chromosomes	3	3a4, 3c1
16	Molecular basis of inheritance	3	3a1, 3c1
17	Gene to protein	3	3a1, 3c1
18	Regulation of gene expression	2, 3, 4	2e1, 3b1, 3b2, 4a3
19	Viruses	3	3a1, 3c3
20	Biotechnology	3	3a1
21	Genomes and their evolution	4	4c1
22	Descent with modification	1	1a1, 1a4
23	Evolution of Populations	1, 3, 4	1a2, 1a3, 3c1, 4c3, 4c4
24	Origin of Species	1, 2, 4	1c1, 1c2, 1c3, 2e2, 4b4, 4c3

Chapter	Title	Big Idea	Essential Knowledge
26	Phylogeny	1	1a4, 1b1, 1d1, 1c1
28	Protists	1	1b2
29	Evolution of plants 1	3	3a1, 3c2
30	Evolution of plants 2	2	2e1, 2e2
40	Animal form and function	2	2d4, 2e2, 2e3
43	Immune system	2, 4	2a1, 2c1, 2c2, 2d2, 2d3, 4b2
44	Osmoregulation	2	2d4
48	Neurons	3, 4	3e2, 4a4
49	Nervous System	3	3e2
51	Animal Behavior	2, 3	2a1, 2ea, 3e1
52	Ecology	2	2d1
53	Population Ecology	2	2a1, 2d1
54	Community ecology	2, 4	2d1, 2e3, 4a5, 4a6, 4b3, 4c4
55	Ecosystems	2, 4	2a1, 2d1, 4a6, 4b4
56	Conservation Biology	2, 4	2d2, 2d3, 4a6, 4b4, 4c4
<p>Big Ideas</p> <p>1: The process of evolution drives the diversity and unity of life</p> <p>2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and maintain homeostasis</p> <p>3: Living systems store, retrieve, transmit, and respond to information essential to life processes</p> <p>4: Biology systems interact and these systems and their interactions possess complex properties</p> <p><b>**Entire chapters are not necessarily covered**</b></p>			

## AP CHEMISTRY – H COURSE DESCRIPTION

### AP CHEMISTRY – H

CREDIT: 1 ½ credits

The AP Chemistry course reflects the recommended AP curriculum and focuses on aqueous chemistry processes, electrochemistry, bonding, kinetics, equilibrium, weak acids and bases, and thermodynamics. Laboratory work is rigorous and integrated throughout the course. Students enrolled in AP Chemistry will be offered the option to take the AP exam in May. Some students enrolled may attend colleges where an Advanced Placement score of 4 or 5 will earn them exemption from, or credit in, general chemistry.

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

#### **BIG IDEA 1: THE CHEMICAL ELEMENTS ARE FUNDAMENTAL BUILDING MATERIALS OF MATTER, AND ALL MATTER CAN BE UNDERSTOOD IN TERMS OF ARRANGEMENTS OF ATOMS. THESE ATOMS RETAIN THEIR IDENTITY IN CHEMICAL REACTIONS.**

**Enduring understanding 1.A:** All matter is made of atoms. There are a limited number of types of atoms; these are the elements.

Essential knowledge 1.A.1: Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions.

Essential knowledge 1.A.2: Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity.

Essential knowledge 1.A.3: The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level

**Enduring understanding 1.B:** The atoms of each element have unique structures arising from interactions between electrons and nuclei.

Essential knowledge 1.B.1: The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's Law is qualitatively useful for understanding the structure of the atom.

Essential knowledge 1.B.2: The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb's Law.

**Enduring understanding 1.C:** Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.

Essential knowledge 1.C.1: Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure.

Essential knowledge 1.C.2: The currently accepted best model of the atom is based on the quantum mechanical model.

**Enduring understanding 1.D:** Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.

Essential knowledge 1.D.1: As is the case with all scientific models, any model of the atom is subject to refinement and change in response to new experimental results. In that sense, an atomic model is not regarded as an exact description of the atom, but rather a theoretical construct that fits a set of experimental data.

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

- Essential knowledge 1.D.2: An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model.
- Essential knowledge 1.D.3: The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration.
- Enduring understanding 1.E: Atoms are conserved in physical and chemical processes. Essential knowledge 1.E.1: Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types.**
- Essential knowledge 1.E.1: Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types.
- Essential knowledge 1.E.2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

#### **BIG IDEA 2: CHEMICAL AND PHYSICAL PROPERTIES OF MATERIALS CAN BE EXPLAINED BY THE STRUCTURE AND THE ARRANGEMENT OF ATOMS, IONS, OR MOLECULES AND THE FORCES BETWEEN THEM.**

- Enduring understanding 2.A: Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.**
- Essential knowledge 2.A.1: The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures.
- Essential knowledge 2.A.2: The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently.
- Essential knowledge 2.A.3: Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.
- Enduring understanding 2.B: Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.**
- Essential knowledge 2.B.1: London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules.
- Essential knowledge 2.B.2: Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force.

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

Essential knowledge 2.B.3: Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions.

**Enduring understanding 2.C: The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.**

Essential knowledge 2.C.1: In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond.

Essential knowledge 2.C.2: Ionic bonding results from the net attraction between oppositely charged ions, closely packed together in a crystal lattice.

Essential knowledge 2.C.3: Metallic bonding describes an array of positively charged metal cores surrounded by a sea of mobile valence electrons.

Essential knowledge 2.C.4: The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model.

**Enduring understanding 2.D: The type of bonding in the solid state can be deduced from the properties of the solid state.**

Essential knowledge 2.D.1: Ionic solids have high melting points, are brittle, and conduct electricity only when molten or in solution.

Essential knowledge 2.D.2: Metallic solids are good conductors of heat and electricity, have a wide range of melting points, and are shiny, malleable, ductile, and readily alloyed.

Essential knowledge 2.D.3: Covalent network solids generally have extremely high melting points, are hard, and are thermal insulators. Some conduct electricity.

Essential knowledge 2.D.4: Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.

### **BIG IDEA 3: CHANGES IN MATTER INVOLVE THE REARRANGEMENT AND/OR REORGANIZATION OF ATOMS AND/OR THE TRANSFER OF ELECTRONS.**

**Enduring understanding 3.A: Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.**

Essential knowledge 3.A.1: A chemical change may be represented by a molecular, ionic, or net ionic equation.

Essential knowledge 3.A.2: Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**Enduring understanding 3.B:** Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.

Essential knowledge 3.B.1: Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat.

Essential knowledge 3.B.2: In a neutralization reaction, protons are transferred from an acid to a base.

Essential knowledge 3.B.3: In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.

**Enduring understanding 3.C:** Chemical and physical transformations may be observed in several ways and typically involve a change in energy.

Essential knowledge 3.C.1: Production of heat or light, formation of a gas, and formation of a precipitate and/ or a color change are possible evidences that a chemical change has occurred.

Essential knowledge 3.C.2: Net changes in energy for a chemical reaction can be endothermic or exothermic.

Essential knowledge 3.C.3: Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells.

#### **BIG IDEA 4: RATES OF CHEMICAL REACTIONS ARE DETERMINED BY DETAILS OF THE MOLECULAR COLLISIONS.**

**Enduring understanding 4.A:** Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time.

Essential knowledge 4.A.1: The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent.

Essential knowledge 4.A.2: The rate law shows how the rate depends on reactant concentrations.

Essential knowledge 4.A.3: The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant.

**Enduring understanding 4.B:** Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products.

Essential knowledge 4.B.1: Elementary reactions can be unimolecular or involve collisions between two or more molecules.

Essential knowledge 4.B.2: Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds.

Essential knowledge 4.B.3: A successful collision can be viewed as following a reaction path with an associated energy profile.



## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

- Essential knowledge 4.B.1: Elementary reactions can be unimolecular or involve collisions between two or more molecules.
- Essential knowledge 4.B.2: Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds.
- Essential knowledge 4.B.3: A successful collision can be viewed as following a reaction path with an associated energy profile.

**Enduring understanding 4.C: Many reactions proceed via a series of elementary reactions.**

- Essential knowledge 4.C.1: The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction.
- Essential knowledge 4.C.2: In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step.
- Essential knowledge 4.C.3: Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions.

**Enduring understanding 4.D: Reaction rates may be increased by the presence of a catalyst.**

- Essential knowledge 4.D.1: Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism.
- Essential knowledge 4.D.2: Important classes in catalysis include acid-base catalysis, surface catalysis, and enzyme catalysis.

***BIG IDEA 5: THE LAWS OF THERMODYNAMICS DESCRIBE THE ESSENTIAL ROLE OF ENERGY AND EXPLAIN AND PREDICT THE DIRECTION OF CHANGES IN MATTER.***

**Enduring understanding 5.A: Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat.**

- Essential knowledge 5.A.1: Temperature is a measure of the average kinetic energy of atoms and molecules.
- Essential knowledge 5.A.2: The process of kinetic energy transfer at the particulate scale is referred to in this course as heat transfer, and the spontaneous direction of the transfer is always from a hot to a cold body.

**Enduring understanding 5.B: Energy is neither created nor destroyed, but only transformed from one form to another.**

- Essential knowledge 5.B.1: Energy is transferred between systems either through heat transfer or through one system doing work on the other system.
- Essential knowledge 5.B.2: When two systems are in contact with each other and are otherwise isolated, the energy that comes out of one system is equal to the energy that goes into the other system. The combined energy of the two systems remains fixed. Energy transfer can occur through either heat exchange or work.

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

Essential knowledge 5.B.3: Chemical systems undergo three main processes that change their energy: heating/ cooling, phase transitions, and chemical reactions.

Essential knowledge 5.B.4: Calorimetry is an experimental technique that is used to measure the change in energy of a chemical system.

**Enduring understanding 5.C: Breaking bonds requires energy, and making bonds releases energy.**

Essential knowledge 5.C.1: Potential energy is associated with a particular geometric arrangement of atoms or ions and the electrostatic interactions between them.

Essential knowledge 5.C.2: The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released.

**Enduring understanding 5.D: Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.**

Essential knowledge 5.D.1: Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force.

Essential knowledge 5.D.2: At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions.

Essential knowledge 5.D.3: Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.

**Enduring understanding 5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.**

Essential knowledge 5.E.1: Entropy is a measure of the dispersal of matter and energy.

Essential knowledge 5.E.2: Some physical or chemical processes involve both a decrease in the internal energy of the components ( $\Delta H^\circ < 0$ ) under consideration and an increase in the entropy of those components ( $\Delta S^\circ > 0$ ). These processes are necessarily “thermodynamically favored” ( $\Delta G^\circ < 0$ ).

Essential knowledge 5.E.3: If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.

Essential knowledge 5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.

Essential knowledge 5.E.5: A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control).

## AP CHEMISTRY – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**BIG IDEA 6: ANY BOND OR INTERMOLECULAR ATTRACTION THAT CAN BE FORMED CAN BE BROKEN. THESE TWO PROCESSES ARE IN A DYNAMIC COMPETITION, SENSITIVE TO INITIAL CONDITIONS AND EXTERNAL PERTURBATIONS.**

**Enduring understanding 6.A: Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.**

Essential knowledge 6.A.1: In many classes of reactions, it is important to consider both the forward and reverse reaction.

Essential knowledge 6.A.2: The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient,  $Q$ .

Essential knowledge 6.A.3: When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. Equilibrium results from an equality between the rates of the forward and reverse reactions, at which point  $Q = K$ .

Essential knowledge 6.A.4: The magnitude of the equilibrium constant,  $K$ , can be used to determine whether the equilibrium lies toward the reactant side or product side.

**Enduring understanding 6.B: Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system.**

Essential knowledge 6.B.1: Systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (LeChatelier's principle).

Essential knowledge 6.B.2: A disturbance to a system at equilibrium causes  $Q$  to differ from  $K$ , thereby taking the system out of the original equilibrium state. The system responds by bringing  $Q$  back into agreement with  $K$ , thereby establishing a new equilibrium state.

**Enduring understanding 6.C: Chemical equilibrium plays an important role in acid-base chemistry and in solubility.**

Essential knowledge 6.C.1: Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry.

Essential knowledge 6.C.2: The pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing pH to  $pK_a$  allows one to determine the protonation state of a molecule with a labile proton.

Essential knowledge 6.C.3: The solubility of a substance can be understood in terms of chemical equilibrium.

**Enduring understanding 6.D: The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products.**

Essential knowledge 6.D.1: When the difference in Gibbs free energy between reactants and products ( $\Delta G^\circ$ ) is much larger than the thermal energy ( $RT$ ), the equilibrium constant is either very small (for  $\Delta G^\circ > 0$ ) or very large (for  $\Delta G^\circ < 0$ ). When  $\Delta G^\circ$  is comparable to the thermal energy ( $RT$ ), the equilibrium constant is near 1.

## AP CHEMISTRY – H

### LEARNING OBJECTIVES

- 1.1 The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory. [See SP 6.1; Essential knowledge 1.A.1]
- 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. [See SP 2.2; Essential knowledge 1.A.2]
- 1.3 The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. [See SP 2.2, 6.1; Essential knowledge 1.A.2]
- 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. [See SP 7.1; Essential knowledge 1.A.3]
- 1.5 The student is able to explain the distribution of electrons in an atom or ion based upon data. [See SP 1.5, 6.2; Essential knowledge 1.B.1]
- 1.6 The student is able to analyze data relating to electron energies for patterns and relationships. [See SP 5.1; Essential knowledge 1.B.1]
- 1.7 The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's Law to construct explanations of how the energies of electrons within shells in atoms vary. [See SP 5.1, 6.2; Essential knowledge 1.B.2]
- 1.8 The student is able to explain the distribution of electrons using Coulomb's Law to analyze measured energies. [See SP 6.2; Essential knowledge 1.B.2]
- 1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. [See SP 6.4; Essential knowledge 1.C.1]
- 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity. [See SP 6.1; Essential knowledge 1.C.1]
- 1.11 The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied. [See SP 3.1, 5.1; Essential knowledge 1.C.1]
- 1.12 The student is able to explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model. [See SP 6.3; Essential knowledge 1.C.2]
- 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence. [See SP 5.3; Essential knowledge 1.D.1]
- 1.14 The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element. [See SP 1.4, 1.5; Essential knowledge 1.D.2]
- 1.15 The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [See SP 4.1; Essential knowledge 1.D.3]
- 1.16 The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [See SP 4.2, 5.1; Essential knowledge 1.D.3]
- 1.17 The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings. [See SP 1.5; Essential knowledge 1.E.1]
- 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes. [See SP 1.4; Essential knowledge 1.E.2]

## AP CHEMISTRY – H LEARNING OBJECTIVES

- 1.19 The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1; Essential knowledge 1.E.2]
- 1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1; Essential knowledge 1.E.2]
- 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views. [See SP 6.4, 7.1; Essential knowledge components of 2.A-2.D]
- 2.2 The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium. [See SP 7.2, connects to Big Idea 5, Big Idea 6; Essential knowledge components of 2.A-2.D]
- 2.3 The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. [See SP 6.4, 7.1; Essential knowledge 2.A.1]
- 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors. [See SP 1.4, 6.4; Essential knowledge 2.A.2]
- 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [See SP 1.3, 6.4, 7.2; Essential knowledge 2.A.2]
- 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. [See SP 2.2, 2.3; Essential knowledge 2.A.2]
- 2.7 The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions. [See SP 6.2; Essential knowledge 2.A.3]
- 2.8 The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent. [See SP 1.1, 1.2, 6.4; Essential knowledge 2.A.3]
- 2.9 The student is able to create or interpret representations that link the concept of molarity with particle views of solutions. [See SP 1.1, 1.4; Essential knowledge 2.A.3]
- 2.10 The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [See SP 4.2, 5.1; Essential knowledge 2.A.3]
- 2.11 The student is able to explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces. [See SP 6.2, 6.4; Essential knowledge 2.B.1]
- 2.12 The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions. [See SP 5.1, 6.5; Essential knowledge 2.B.2, connects to 2.A.2]
- 2.13 The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles
- 2.14 The student is able to apply Coulomb's Law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds. [See SP 1.4, 6.4; Essential knowledge 2.B.2]
- 2.15 The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects. [See SP 1.4, 6.2; Essential knowledge 2.B.3, connects to 5.E.1]

## AP CHEMISTRY – H

### LEARNING OBJECTIVES

- 2.16 The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces. [See SP 6.2; Essential knowledge 2.B.3]
- 2.17 The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements. [See SP 6.4; Essential knowledge components of 2.C]
- 2.18 The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table. [See SP 6.1; Essential knowledge 2.C.1]
- 2.19 The student can create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity). [See SP 1.1, 1.4, 7.1; Essential knowledge 2.C.2, connects to 2.D.1, 2.D.2]
- 2.20 The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom. [See SP 6.2, 7.1; Essential knowledge 2.C.3, connects to 2.D.2]
- 2.21 The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity. [See SP 1.4; Essential knowledge 2.C.4]
- 2.22 The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid. [See SP 4.2; Essential knowledge components of 2.D]
- 2.23 The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance. [See SP 1.1; Essential knowledge 2.D.1]
- 2.24 The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level. [See SP 1.1, 6.2, 7.1; Essential knowledge 2.D.1]
- 2.25 The student is able to compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning. [See SP 1.4, 7.2; Essential knowledge 2.D.2]
- 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys. [See SP 6.4, 7.1; Essential knowledge 2.D.2]
- 2.27 The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance. [See SP 1.1; Essential knowledge 2.D.2]
- 2.28 The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level. [See SP 1.1, 6.2, 7.1; Essential knowledge 2.D.2]
- 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance. [See SP 1.1; Essential knowledge 2.D.3]
- 2.30 The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level. [See SP 1.1, 6.2, 7.1; Essential knowledge 2.D.3]
- 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. [See SP 1.1; Essential knowledge 2.D.4]

## AP CHEMISTRY – H

### LEARNING OBJECTIVES

- 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level. [See SP 1.1, 6.2, 7.1; Essential knowledge 2.D.4]
- 3.1 Students can translate among macroscopic observations of change, chemical equations, and particle views. [See SP 1.5, 7.1; Essential knowledge components of 3.A-3.C]
- 3.2 The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. [See SP 1.5, 7.1; Essential knowledge 3.A.1]
- 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. [See SP 2.2, 5.1; Essential knowledge 3.A.2]
- 3.4 The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. [See SP 2.2, 5.1, 6.4; Essential knowledge 3.A.2]
- 3.5 The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. [See SP 2.1, 4.2; Essential knowledge 3.B.1]
- 3.6 The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. [See SP 2.2, 6.1; Essential knowledge 3.B.1]
- 3.7 The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification. [See SP 6.1; Essential knowledge 3.B.2]
- 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer. [See SP 6.1; Essential knowledge 3.B.3]
- 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration. [See SP 4.2, 5.1; Essential knowledge 3.B.3]
- 3.10 The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions. [See SP 1.4, 6.1; Essential knowledge 3.C.1, connects to 5.D.2]
- 3.11 The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes. [See SP 1.5, 4.4; Essential knowledge 3.C.2]
- 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws. [See SP 2.2, 2.3, 6.4; Essential knowledge 3.C.3]
- 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. [See SP 5.1; Essential knowledge 3.C.3]
- 4.1 The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. [See SP 4.2, 5.1; Essential knowledge 4.A.1]
- 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. [See SP 5.1; Essential knowledge 4.A.2, connects to 4.A.3]
- 4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. [See SP 2.1, 2.2; Essential knowledge 4.A.3]

## AP CHEMISTRY – H

### LEARNING OBJECTIVES

- 4.4 The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively. [See SP 7.1; Essential knowledge 4.B.1, connects to 4.A.3, 4.B.2]
- 4.5 The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation. [See SP 6.2; Essential knowledge 4.B.2]
- 4.6 The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate. [See SP 1.4, 6.4; Essential knowledge 4.B.3]
- 4.7 The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate. [See SP 6.5; connects to Essential knowledge 4.C.1, 4.C.2, 4.C.3]
- 4.8 The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. [See SP 1.5; Essential knowledge 4.D.1]
- 4.9 The student is able to explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present. [See SP 6.2, 7.2; Essential knowledge 4.D.2]
- 5.1 The student is able to create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength. [See SP 1.1, 1.4, 7.2, connects to Big Idea 2; Essential knowledge components of 5.A-5.E]
- 5.2 The student is able to relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution. [See SP 1.1, 1.4, 7.1; Essential knowledge 5.A.1]
- 5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. [See SP 7.1; Essential knowledge 5.A.2]
- 5.4 The student is able to use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. [See SP 1.4, 2.2, connects to Essential knowledge 5.B.1, 5.B.2]
- 5.5 The student is able to use conservation of energy to relate the magnitudes of the energy changes when two non-reacting substances are mixed or brought into contact with one another. [See SP 2.2, connects to Essential knowledge 5.B.1, 5.B.2]
- 5.6 The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to  $P\Delta V$  work. [See SP 2.2, 2.3; Essential knowledge 5.B.3]
- 5.7 The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. [See SP 4.2, 5.1; Essential knowledge 5.B.4]
- 5.8 The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. [See SP 2.3, 7.1, 7.2; Essential knowledge 5.C.2]



## AP CHEMISTRY – H

### LEARNING OBJECTIVES

- 5.9 The student is able to make claims and/or predictions regarding relative magnitudes of the forces acting within collections of interacting molecules based on the distribution of electrons within the molecules and the types of intermolecular forces through which the molecules interact. [See SP 6.4; Essential knowledge 5.D.1]
- 5.10 The student can support the claim about whether a process is a chemical or physical change (or may be classified as both) based on whether the process involves changes in intramolecular versus intermolecular interactions. [See SP 5.1; Essential knowledge 5.D.2]
- 5.11 The student is able to identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions. [See SP 7.2; Essential knowledge 5.D.3]
- 5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. [See SP 1.4; Essential knowledge 5.E.1]
- 5.13 The student is able to predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both  $\Delta H^\circ$  and  $\Delta S^\circ$ , and calculation or estimation of  $\Delta G^\circ$  when needed. [See SP 2.2, 2.3, 6.4; Essential knowledge 5.E.2, connects to 5.E.3]
- 5.14 The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. [See SP 2.2; Essential knowledge 5.E.3, connects to 5.E.2]
- 5.15 The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. [See SP 6.2; Essential knowledge 5.E.4]
- 5.16 The student can use LeChatelier's principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product. [See SP 6.4; Essential knowledge 5.E.4, connects to 6.B.1]
- 5.17 The student can make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. [See SP 6.4; Essential knowledge 5.E.4, connects to 6.A.2]
- 5.18 The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions. [See SP 1.3, 7.2; Essential knowledge 5.E.5, connects to 6.D.1]
- 6.1 The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. [See SP 6.2; Essential knowledge 6.A.1]
- 6.2 The student can, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on Q or K. [See SP 2.2; Essential knowledge 6.A.2]
- 6.3 The student can connect kinetics to equilibrium by using reasoning about equilibrium, such as LeChatelier's principle, to infer the relative rates of the forward and reverse reactions. [See SP 7.2; Essential knowledge 6.A.3]
- 6.4 The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached. [See SP 2.2, 6.4; Essential knowledge 6.A.3]

## AP CHEMISTRY – H LEARNING OBJECTIVES

- 6.5 The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant,  $K$ . [See SP 2.2; Essential knowledge 6.A.3]
- 6.6 The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant,  $K$ , use stoichiometric relationships and the law of mass action ( $Q$  equals  $K$  at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction. [See SP 2.2, 6.4; Essential knowledge 6.A.3]
- 6.7 The student is able, for a reversible reaction that has a large or small  $K$ , to determine which chemical species will have very large versus very small concentrations at equilibrium. [See SP 2.2, 2.3; Essential knowledge 6.A.4]
- 6.8 The student is able to use LeChatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. [See SP 1.4, 6.4; Essential knowledge 6.B.1]
- 6.9 The student is able to use LeChatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. [See SP 4.2; Essential knowledge 6.B.1]
- 6.10 The student is able to connect LeChatelier's principle to the comparison of  $Q$  to  $K$  by explaining the effects of the stress on  $Q$  and  $K$ . [See SP 1.4, 7.2; Essential knowledge 6.B.2]
- 6.11 The student can generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium. [See SP 1.1, 1.4, 2.3; Essential knowledge 6.C.1]
- 6.12 The student can reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [See SP 1.4; Essential knowledge 6.C.1, connects to 1.E.2]
- 6.13 The student can interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the  $pK_a$  for a weak acid, or the  $pK_b$  for a weak base. [See SP 5.1; Essential knowledge 6.C.1, connects to 1.E.2]
- 6.14 The student can, based on the dependence of  $K_w$  on temperature, reason that neutrality requires  $[H^+] = [OH^-]$  as opposed to requiring  $pH = 7$ , including especially the applications to biological systems. [See SP 2.2, 6.2; Essential knowledge 6.C.1]
- 6.15 The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.1]
- 6.16 The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. [See SP 2.2, 6.4; Essential knowledge 6.C.1]
- 6.17 The student can, given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with  $K > 1$ ) and what species will be present in large concentrations at equilibrium. [See SP 6.4; Essential knowledge 6.C.1]
- 6.18 The student can design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. [See SP 2.3, 4.2, 6.4; Essential knowledge 6.C.2]

## AP CHEMISTRY – H LEARNING OBJECTIVES

- 6.19 The student can relate the predominant form of a chemical species involving a labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a solution and the pKa associated with the labile proton. [See SP 2.3, 5.1, 6.4; Essential knowledge 6.C.2]
- 6.20 The student can identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base. [See SP 6.4; Essential knowledge 6.C.2]
- 6.21 The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant Ksp values. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.3]
- 6.22 The student can interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.3]
- 6.23 The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. [See SP 5.1; Essential knowledge 6.C.3]
- 6.24 The student can analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. [See SP 1.4, 7.1; Essential knowledge 6.C.3, connects to 5.E]
- 6.25 The student is able to express the equilibrium constant in terms of  $\Delta G^\circ$  and  $RT$  and use this relationship to estimate the magnitude of  $K$  and, consequently, the thermodynamic favorability of the process. [See SP 2.3; Essential knowledge 6.D.1]

**AP CHEMISTRY – H**  
**UNIT 1: REVIEW OF ADVANCED CHEMISTRY BASICS**

**Big Ideas:**

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ All matter is made of atoms. There are a limited number of types of atoms; these are the elements.</li> <li>▪ Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.</li> <li>▪ Atoms are conserved in physical and chemical processes.</li> <li>▪ Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.</li> <li>▪ Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Mystery Solutions</li> <li>▪ Graphing Periodic Table Trends</li> <li>▪ Synthesis of Green Salt Crystals Lab</li> <li>▪ Separation of a Salt Mixture and % Composition Lab</li> <li>▪ Analysis of % Water in Green Salt Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.</li> <li>▪ The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.</li> <li>▪ The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.</li> <li>▪ The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.</li> <li>▪ The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings.</li> <li>▪ The student is able to apply conservation of atoms to the rearrangement of atoms in various processes.</li> <li>▪ Students can translate among macroscopic observations of change, chemical equations, and particle views.</li> <li>▪ The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.</li> <li>▪ The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.</li> <li>▪ The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.</li> </ul>

## AP CHEMISTRY – H

### UNIT 2: PREDICTING PRODUCTS AND WRITING BALANCED CHEMICAL EQUATIONS

*Emphasis is placed on classifying a reaction as one of several basic types, and predicting products that could form, given only the reactants. How to write balanced chemical equations for redox reactions by various methods is presented. Calculations are used to find which reactant is in excess and how to use this limiting factor to determine the amount of product(s) that will be formed and determining the percent yield of actual product.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ All matter is made of atoms. There are a limited number of types of atoms; these are the elements.</li> <li>▪ Atoms are conserved in physical and chemical processes.</li> <li>▪ Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.</li> <li>▪ Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants</li> </ul>	<ul style="list-style-type: none"> <li>▪ One Tube Reactions Lab</li> <li>▪ Guided Inquiry – Mission Impossible Lab</li> <li>▪ Standardization of NaOH Lab</li> <li>▪ Determination of %K and %Fe in Green Salt Crystal Ion</li> <li>▪ Exchange and NaOH Titration Lab</li> <li>▪ <i>Guided Inquiry</i></li> <li>▪ Standardization of <math>\text{KMnO}_4</math> with FAS (Redox Titration) Lab</li> <li>▪ How Can We Determine % <math>\text{H}_2\text{O}_2</math> in Drugstore Bottle? Lab</li> <li>▪ Lab Analysis Complex Salt Crystals - % oxalate, empirical formula and % yield</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.</li> <li>▪ The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings.</li> <li>▪ The student is able to apply conservation of atoms to the rearrangement of atoms in various processes.</li> <li>▪ The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.</li> <li>▪ The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.</li> <li>▪ The student is able to create or interpret representations that link the concept of molarity with particle views of solutions.</li> <li>▪ The student is able to apply Coulomb’s Law</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 2: PREDICTING PRODUCTS AND WRITING BALANCED CHEMICAL EQUATIONS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>react and products form.</p> <ul style="list-style-type: none"> <li>▪ Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.</li> <li>▪ Chemical and physical transformations may be observed in several ways and typically involve a change in energy.</li> <li>▪ Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.</li> <li>▪ Chemical equilibrium plays an important role in acid-base chemistry and in solubility.</li> </ul>		<p>qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds.</p> <ul style="list-style-type: none"> <li>▪ Students can translate among macroscopic observations of change, chemical equations, and particle views.</li> <li>▪ The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances.</li> <li>▪ The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.</li> <li>▪ The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.</li> <li>▪ The student is able to identify redox reactions and justify the identification in terms of electron transfer.</li> <li>▪ The student is able to design and/or interpret the results of an experiment involving a redox titration.</li> <li>▪ The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.</li> </ul>

## AP CHEMISTRY – H

### UNIT 3: CHEMICAL EQUILIBRIA

*Conditions for both physical and chemical equilibrium systems will be studied. LeChatelier's principle is applied to analyze how the system responds to stresses placed upon it. The equilibrium between concentrations of the hydronium and hydroxide ions in solutions is studied and related to the pH values.  $K_{eq}$ ,  $K_w$ ,  $K_a$ ,  $K_b$  and  $K_{sp}$  calculations are used to predict the degree of completeness for reactions in solutions.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.</li> <li>▪ Atoms are conserved in physical and chemical processes.</li> <li>▪ Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.</li> <li>▪ Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Le Chatelier's Lab Guided Inquiry</li> <li>▪ Determination of <math>K_c</math> of <math>Fe^{3+}</math> and <math>SCN^-</math> Lab</li> <li>▪ Acid-Base Titration to Determine Unknown Diprotic Acid Lab</li> <li>▪ Preparing Acetic Acid/Acetate Buffer System Lab</li> <li>▪ Using a Spectrophotometer and Beer's Law to Find <math>K_{sp}</math> of <math>PbI_2</math></li> </ul>	<ul style="list-style-type: none"> <li>▪ The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution.</li> <li>▪ The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.</li> <li>▪ Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.</li> <li>▪ The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium.</li> <li>▪ The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.</li> <li>▪ The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 3: CHEMICAL EQUILIBRIA**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.</li> <li>▪ Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.</li> <li>▪ Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.</li> <li>▪ Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system.</li> <li>▪ Chemical equilibrium plays an important role in acid-base chemistry and in solubility.</li> </ul>		<ul style="list-style-type: none"> <li>▪ The student can use LeChatelier’s principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product.</li> <li>▪ The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes.</li> <li>▪ The student can, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on Q or K.</li> <li>▪ The student can connect kinetics to equilibrium by using reasoning about equilibrium, such as LeChatelier’s principle, to infer the relative rates of the forward and reverse reactions.</li> <li>▪ The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached.</li> <li>▪ The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K.</li> <li>▪ The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use stoichiometric relationships and the law of mass action (Q equals K at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible</li> </ul>



**AP CHEMISTRY – H**  
**UNIT 3: CHEMICAL EQUILIBRIA**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<p>reaction.</p> <ul style="list-style-type: none"> <li>▪ The student is able, for a reversible reaction that has a large or small K, to determine which chemical species will have very large versus very small concentrations at equilibrium.</li> <li>▪ The student is able to use LeChatelier’s principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium.</li> <li>▪ The student is able to use LeChatelier’s principle to design a set of conditions that will optimize a desired outcome, such as product yield.</li> <li>▪ The student is able to connect LeChatelier’s principle to the comparison of Q to K by explaining the effects of the stress on Q and K.</li> <li>▪ The student can generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium.</li> <li>▪ The student can reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration.</li> <li>▪ The student can interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base.</li> <li>▪ The student can, based on the dependence of Kw on temperature, reason that neutrality requires <math>[H^+] = [OH^-]</math> as opposed to requiring pH = 7, including especially the applications to biological systems.</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 3: CHEMICAL EQUILIBRIA**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<ul style="list-style-type: none"> <li>▪ The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution.</li> <li>▪ The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations.</li> <li>▪ The student can, given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with <math>K &gt; 1</math>) and what species will be present in large concentrations at equilibrium.</li> <li>▪ The student can design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity.</li> <li>▪ The student can relate the predominant form of a chemical species involving a labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a solution and the <math>pK_a</math> associated with the labile proton.</li> <li>▪ The student can identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base.</li> <li>▪ The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant <math>K_{sp}</math> values.</li> <li>▪ The student can interpret data regarding solubility of salts to determine, or rank, the relevant <math>K_{sp}</math> values.</li> <li>▪ The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility.</li> </ul>

## AP CHEMISTRY – H

### UNIT 4: THERMODYNAMICS

*The nature of exothermic versus endothermic reactions will be studied by calorimetry experiments. Hess' Law will be applied to calculate energy changes that occur. Entropy changes will be examined as a driving force in opposition to enthalpy changes. Thermodynamics also plays a role in the establishment of equilibrium systems. Enthalpy, entropy and Gibb's free energy will be used to predict the spontaneity of reactions and the ability of the system to do work on its surroundings.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The atoms of each element have unique structures arising from interactions between electrons and nuclei.</li> <li>▪ Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.</li> <li>▪ Atoms are so small that they are</li> </ul>	<ul style="list-style-type: none"> <li>▪ Handwarmer Design Challenge</li> <li>▪ Guided Inquiry Lab</li> <li>▪ Thermodynamics of <math>K_{sp}</math> of Borax Solution Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's Law to construct explanations of how the energies of electrons within shells in atoms vary.</li> <li>▪ The student is able to explain the distribution of electrons using Coulomb's Law to analyze measured energies.</li> <li>▪ Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.</li> <li>▪ The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.</li> <li>▪ The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.</li> <li>▪ The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 4: THERMODYNAMICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.</p> <ul style="list-style-type: none"> <li>▪ Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.</li> <li>▪ The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.</li> <li>▪ The type of bonding in the solid state can be deduced from the properties of the solid state.</li> <li>▪ Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat.</li> <li>▪ Breaking bonds requires energy, and making bonds releases energy.</li> <li>▪ Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.</li> <li>▪ Chemical or physical processes are driven by a decrease in enthalpy or</li> </ul>		<p>the elements.</p> <ul style="list-style-type: none"> <li>▪ The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.</li> <li>▪ The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.</li> <li>▪ The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.</li> <li>▪ The student is able to create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength.</li> <li>▪ The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.</li> <li>▪ The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds.</li> <li>▪ The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes.</li> <li>▪ The student is able to predict whether or not a physical or</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 4: THERMODYNAMICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>an increase in entropy, or both.</p> <ul style="list-style-type: none"> <li>▪ The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products.</li> </ul>		<p>chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both <math>\Delta H^\circ</math> and <math>\Delta S^\circ</math>, and calculation or estimation of <math>\Delta G^\circ</math> when needed.</p> <ul style="list-style-type: none"> <li>▪ The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy.</li> <li>▪ The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable.</li> <li>▪ The student can use LeChatelier’s principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product.</li> <li>▪ The student can make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction.</li> <li>▪ The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions.</li> <li>▪ The student is able to express the equilibrium constant in terms of <math>\Delta G^\circ</math> and <math>RT</math> and use this relationship to estimate the magnitude of <math>K</math> and, consequently, the thermodynamic favorability of the process.</li> </ul>

## AP CHEMISTRY – H

### UNIT 5: ENERGY AND THE ATOM

*Electron energy level changes and their relationships to the frequency, wavelength or energy of a photon of EMR are determined. The Quantum Model of the atom and electron configurations will be used to predict reactivity and properties of the elements. Energy changes during the formation of chemical bonds will be explored and various bond theories will be considered to explain the properties of elements and compounds.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The atoms of each element have unique structures arising from interactions between electrons and nuclei.</li> <li>▪ Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.</li> <li>▪ Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of</li> </ul>	<ul style="list-style-type: none"> <li>▪ Determination of % Cu in Brass Guided Inquiry Lab</li> <li>▪ VSEPR Origami</li> <li>▪ Belt of Stability Activity</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to explain the distribution of electrons in an atom or ion based upon data.</li> <li>▪ The student is able to analyze data relating to electron energies for patterns and relationships.</li> <li>▪ The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb’s Law to construct explanations of how the energies of electrons within shells in atoms vary.</li> <li>▪ The student is able to explain the distribution of electrons using Coulomb’s Law to analyze measured energies.</li> <li>▪ The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model.</li> <li>▪ Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.</li> <li>▪ The student is able to explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model.</li> <li>▪ Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 5: ENERGY AND THE ATOM**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>atoms.</p> <ul style="list-style-type: none"> <li>▪ The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.</li> <li>▪ The type of bonding in the solid state can be deduced from the properties of the solid state.</li> <li>▪ Breaking bonds requires energy, and making bonds releases energy.</li> <li>▪ Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.</li> </ul>		<ul style="list-style-type: none"> <li>▪ The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules.</li> <li>▪ Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.</li> <li>▪ The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.</li> <li>▪ The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements.</li> <li>▪ The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.</li> <li>▪ The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.</li> <li>▪ The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.</li> <li>▪ The student is able to create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength.</li> <li>▪ The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds.</li> </ul>

## AP CHEMISTRY – H

### UNIT 6: CHEMICAL KINETICS

*How to control the rates of chemical reactions and determine the rate law equations will be studied. The effects of changing concentrations, temperature or addition of catalysts will be studied to determine the effects on the reaction rates.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 4: Rates of chemical reactions are determined by details of the molecular collisions.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ All matter is made of atoms. There are a limited number of types of atoms; these are the elements.</li> <li>▪ Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time.</li> <li>▪ Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products.</li> <li>▪ Many reactions proceed via a series of elementary reactions.</li> <li>▪ Reaction rates may be increased by the presence of a catalyst.</li> </ul>	<ul style="list-style-type: none"> <li>▪ All Screwed Up Activity</li> <li>▪ Graphical Analysis of Iodine Clock Reaction Lab</li> <li>▪ Iodination of Acetone Lab</li> <li>▪ Kinetics of Decomposition of Thiosulfate Ion with H<sup>+</sup> Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.</li> <li>▪ The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.</li> <li>▪ The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.</li> <li>▪ The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction.</li> <li>▪ The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively.</li> <li>▪ The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation.</li> <li>▪ The student is able to use representations of the energy profile for an elementary reaction (from the</li> </ul>



**AP CHEMISTRY – H**  
**UNIT 6: CHEMICAL KINETICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<p>reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate.</p> <ul style="list-style-type: none"> <li>▪ The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate.</li> <li>▪ The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst.</li> <li>▪ The student is able to explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present.</li> </ul>

## AP CHEMISTRY – H UNIT 7: GASES

*The differences between a solid, liquid and a gas on the molecular level are discussed. Mathematical relationships to determine gaseous pressure, temperature, molecular velocity, volume or number of moles of a gas when experimental conditions change are illustrated. Further calculations of the molar mass, molar volume or density of a gas using the gas laws are demonstrated. The gas laws are used to solve stoichiometry problems involving gaseous reactants or products.*

### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ All matter is made of atoms. There are a limited number of types of atoms; these are the elements.</li> <li>▪ Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.</li> <li>▪ Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.</li> <li>▪ Chemical changes are represented by</li> </ul>	<ul style="list-style-type: none"> <li>▪ Gas Laws Jigsaw</li> <li>▪ Determination of % NaHCO<sub>3</sub> in Alka-Seltzer</li> <li>▪ Ammonia/HCl Straw Reaction</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.</li> <li>▪ The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.</li> <li>▪ The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors.</li> <li>▪ The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample.</li> <li>▪ The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases.</li> <li>▪ The student can qualitatively analyze data regarding</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 7: GASES**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>a balanced chemical equation that identifies the ratios with which reactants react and products form.</p> <ul style="list-style-type: none"> <li>▪ Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat.</li> </ul>		<p>real gases to identify deviations from ideal behavior and relate these to molecular interactions.</p> <ul style="list-style-type: none"> <li>▪ The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.</li> <li>▪ The student is able to relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution.</li> </ul>

## AP CHEMISTRY – H

### UNIT 8: OTHER TWO PHASES OF MATTER: LIQUIDS AND SOLIDS

*Phase changes, such as evaporation and condensation, are examined as physical equilibrium systems and Le Châtelier’s principle is applied to analyze how the system responds. The driving forces towards lower enthalpy or higher entropy are related to the thermodynamically favored reaction. Phase diagrams and heating curves are used to determine melting points, boiling points, critical temperatures, critical pressures, and triple points for any substance at various experimental conditions. Conditions that favor the formation of solids, liquids or gases are discussed.*

#### Big Ideas:

- 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions
- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ 1.C Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.</li> <li>▪ 2.A Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Investigation of Intermolecular Forces Explore Activity</li> <li>▪ IMF Simulation</li> <li>▪ What’s in That Bottle? Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied.</li> <li>▪ The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials.</li> <li>▪ The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions.</li> <li>▪ The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components.</li> <li>▪ The student is able to explain the trends in properties and/or predict properties of samples consisting of</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 8: OTHER TWO PHASES OF MATTER: LIQUIDS AND SOLIDS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>that make up the substance and the forces of attraction among them.</p> <ul style="list-style-type: none"> <li>▪ 2.B Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.</li> <li>▪ 2.C The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.</li> <li>▪ 2.D The type of bonding in the solid state can be deduced from the properties of the solid state.</li> <li>▪ 5.B Energy is neither created nor destroyed, but only transformed from one form to another.</li> <li>▪ 5.D Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.</li> <li>▪ 6.A Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.</li> <li>▪ 6.C Chemical equilibrium plays an important role in acid-base chemistry and in solubility.</li> </ul>		<p>particles with no permanent dipole on the basis of London dispersion forces.</p> <ul style="list-style-type: none"> <li>▪ The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.</li> <li>▪ The student is able to apply Coulomb's Law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds.</li> <li>▪ The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.</li> <li>▪ The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces.</li> <li>▪ The student can create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity).</li> <li>▪ The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom.</li> <li>▪ The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 8: OTHER TWO PHASES OF MATTER: LIQUIDS AND SOLIDS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<ul style="list-style-type: none"> <li>▪ The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.</li> <li>▪ Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.</li> <li>▪ The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level.</li> <li>▪ The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level.</li> <li>▪ The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance.</li> <li>▪ The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.</li> </ul>

## AP CHEMISTRY – H

### UNIT 9: ELECTROCHEMISTRY

*Redox reactions will be used to produce electrical energy by creating various types of batteries, called electrochemical cells. Electrolysis, electroplating and corrosion reactions will be studied. Calculations to predict the voltages involved under various experimental conditions will be explored.*

#### Big Ideas:

- 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ 3.B Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.</li> <li>▪ 3.C Chemical and physical transformations may be observed in several ways and typically involve a change in energy.</li> <li>▪ 5.E Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.</li> <li>▪ 6.A Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.</li> <li>▪ 6.C Chemical equilibrium plays an important role in acid-base chemistry and in solubility.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Activity Series Simulation Activity</li> <li>▪ Building Simple Galvanic Cells Lab</li> <li>▪ Emf and the Nernst Equation Lab</li> <li>▪ What Products Form When Separating Solutions by Electrolysis? Lab</li> <li>▪ Electrolysis and Determination of Faraday's Constant and Avogadro's Number Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to identify redox reactions and justify the identification in terms of electron transfer.</li> <li>▪ The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws.</li> <li>▪ The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.</li> <li>▪ The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy.</li> <li>▪ The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable.</li> <li>▪ The student is able, for a reversible reaction that has a large or small K, to determine which chemical species will have very large versus very small concentrations at equilibrium.</li> <li>▪ The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant K<sub>sp</sub> values.</li> </ul>

**AP CHEMISTRY – H**  
**UNIT 10: MATERIALS SCIENCE**

*Characteristics and properties of modern materials, including polymers, colloids, crystals, alloys and ceramics will be examined. Intermolecular forces, chemical bonding and related gas laws will be discussed to explain these properties.*

**Big Ideas:**

2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"><li>▪ Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.</li></ul>	<ul style="list-style-type: none"><li>▪ Vapor Pressure and Determination of Enthalpy of Vaporization Dry Lab</li><li>▪ Using Freezing Point Depression to Identify Unknown Acid Lab</li></ul>	<ul style="list-style-type: none"><li>▪ The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.</li></ul>



**AP CHEMISTRY – H**  
**UNIT 11: ORGANIC CHEMISTRY AND BIOCHEMISTRY**

*Methods of naming organic compounds using the IUPAC system, how to draw structural formulas and how to recognize the different classes of organic compounds is addressed. Descriptions of the general types of organic reactions that can occur are used to predict chemical changes that will take place. Lab analysis techniques will be studied to identify organic compounds. Biochemical molecules and reactions will be examined to determine the type of changes in functional groups involved.*

**Big Ideas:**

- 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.</li> <li>▪ Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Making Organic Compounds Lab</li> <li>▪ Tie-Dye Lab</li> </ul>	<ul style="list-style-type: none"> <li>▪ The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.</li> <li>▪ The student is able to identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions.</li> </ul>

## AP CHEMISTRY – H RESOURCES

- Books
  - Brown, Lemay et al., Chemistry: The Central Science 13th Edition ©2015
  - “Fast Track to a 5: Preparing for the AP Chemistry Examination” by Steven S. Zumdahl (Author), Susan A. Zumdahl (Author), Laura L. Duncan (Author)
  - *College Board “AP Chemistry Guided Inquiry Experiments: Applying the Science Practices” Teacher Lab Manual*
  - *College Board “AP Chemistry Guided Inquiry Experiments: Applying the Science Practices” Student Lab Manual*
- Software
  - MasteringChemistry with Pearson eText
- Videos
  - Ted Talks
  - Assorted YouTube videos
  - Assorted interactive animations
- Magazines
  - ChemMatters
  - Journal of Chemical Education
- Websites
  - Various simulations via <https://phet.colorado.edu/en/simulations/category/new>
  - Other selected websites and electronic media
- Equipment
  - Vernier pH Sensor
  - Vernier LabPro Interface
- Supplies
  - Regular laboratory chemicals and equipment typical of chemistry classroom

**AP CHEMISTRY – H  
PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>	<b>3<sup>rd</sup> Quarter</b>	<b>4<sup>th</sup> Quarter</b>
Unit 1: Review of Advanced Chemistry	X			
Unit 2: Predicting Products and Writing Balanced Chemical Equations	X			
Unit 3: Chemical Equilibria	X	>		
Unit 4: Thermodynamics		X		
Unit 5: Energy and the Atom		X	>	
Unit 6: Chemical Kinetics			X	
Unit 7: Gases			X	
Unit 8: Other Two Phases of Matter: Liquids and Solids			X	
Unit 9: Electrochemistry			X	>
Unit 10: Materials Science				X
Unit 11: Organic Chemistry				X

## **AP PHYSICS III – H COURSE DESCRIPTION**

### **AP PHYSICS III - H**

CREDIT: 1 credit

This is a yearlong course which focuses on the big ideas typically included in the first semester of algebra-based, college level physics. Students will cultivate their understanding of physics as they explore Thermodynamics, ideal gases, kinetic theory, fluid statics and dynamics, electrostatics, DC and RC circuits, electromagnetic inductions, optics, quantum physics, and nuclear physics. This course is recommended for students intending to pursue a post high school degree in engineering or related fields. Students will have the opportunity to take the Physics 2 AP exam in May.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

#### **BIG IDEA 1: OBJECTS AND SYSTEMS HAVE PROPERTIES SUCH AS MASS AND CHARGE. SYSTEMS MAY HAVE INTERNAL STRUCTURE.**

**Enduring Understanding 1.A:** The internal structure of a system determines many properties of the system.

Essential Knowledge 1.A.2: Fundamental particles have no internal structure.

Essential Knowledge 1.A.3: Nuclei have internal structures that determine their properties.

Essential Knowledge 1.A.4: Atoms have internal structures that determine their properties.

Essential Knowledge 1.A.5: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.

**Enduring Understanding 1.B:** Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.

Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.

Essential Knowledge 1.B.2: There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge.

Essential Knowledge 1.B.3: The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.

**Enduring Understanding 1.C:** Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

Essential Knowledge 1.C.4: In certain processes, mass can be converted to energy and energy can be converted to mass according to  $E = mc^2$ , the equation derived from the theory of special relativity.

**Enduring Understanding 1.D:** Classical mechanics cannot describe all properties of objects.

Essential Knowledge 1.D.1: Objects classically thought of as particles can exhibit properties of waves.

Essential Knowledge 1.D.2: Certain phenomena classically thought of as waves can exhibit properties of particles.

Essential Knowledge 1.D.3: Properties of space and time cannot always be treated as absolute.

**Enduring Understanding 1.E:** Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.

Essential Knowledge 1.E.1: Matter has a property called density.

Essential Knowledge 1.E.2: Matter has a property called resistivity.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

- Essential Knowledge 1.E.3: Matter has a property called thermal conductivity.
- Essential Knowledge 1.E.4: Matter has a property called electric permittivity.
- Essential Knowledge 1.E.5: Matter has a property called magnetic permeability.
- Essential Knowledge 1.E.6: Matter has a property called magnetic dipole moment.

#### **BIG IDEA 2: FIELDS EXISTING IN SPACE CAN BE USED TO EXPLAIN INTERACTIONS.**

**Enduring Understanding 2.A:** A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena.

- Essential Knowledge 2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector .
- Essential Knowledge 2.A.2: A scalar field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a scalar. In Physics 2, this should include electric potential.

**Enduring Understanding 2.C:** An electric field is caused by an object with electric charge.

- Essential Knowledge 2.C.1: The magnitude of the electric force  $F$  exerted on an object with electric charge  $q$  by an electric field  $F q = E$ . The direction of the force is determined by the direction of the field and the sign of the charge, with positively charged objects accelerating in the direction of the field and negatively charged objects accelerating in the direction opposite the field. This should include a vector field map for positive point charges, negative point charges, spherically symmetric charge distribution, and uniformly charged parallel plates.
- Essential Knowledge 2.C.2: The magnitude of the electric field vector is proportional to the net electric charge of the object(s) creating that field. This includes positive point charges, negative point charges, spherically symmetric charge distributions, and uniformly charged parallel plates.
- Essential Knowledge 2.C.3: The electric field outside a spherically symmetric charged object is radial, and its magnitude varies as the inverse square of the radial distance from the center of that object. Electric field lines are not in the curriculum. Students will be expected to rely only on the rough intuitive sense underlying field lines, wherein the field is viewed as analogous to something emanating uniformly from a source.
- Essential Knowledge 2.C.4: The electric field around dipoles and other systems of electrically charged objects (that can be modeled as point objects) is found by vector addition of the field of each individual object. Electric dipoles are treated qualitatively in this course as a teaching analogy to facilitate student understanding of magnetic dipoles.
- Essential Knowledge 2.C.5: Between two oppositely charged parallel plates with uniformly distributed electric charge, at points far from the edges of the plates, the electric field is perpendicular to the plates and is constant in both magnitude and direction.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**Enduring Understanding 2.D:** A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles.

Essential Knowledge 2.D.1: The magnetic field exerts a force on a moving electrically charged object. That magnetic force is perpendicular to the direction of velocity of the object and to the magnetic field and is proportional to the magnitude of the charge, the magnitude of the velocity and the magnitude of the magnetic field. It also depends on the angle between the velocity, and the magnetic field vectors. Treatment is quantitative for angles of  $0^\circ$ ,  $90^\circ$ , or  $180^\circ$  and qualitative for other angles.

Essential Knowledge 2.D.2: The magnetic field vectors around a straight wire that carries electric current are tangent to concentric circles centered on that wire. The field has no component toward the current-carrying wire.

Essential Knowledge 2.D.3: A magnetic dipole placed in a magnetic field, such as the ones created by a magnet or the Earth, will tend to align with the magnetic field vector.

Essential Knowledge 2.D.4: Ferromagnetic materials contain magnetic domains that are themselves magnets.

**Enduring Understanding 2.E:** Physicists often construct a map of isolines connecting points of equal value for some quantity related to a field and use these maps to help visualize the field.

Essential Knowledge 2.E.1: Isolines on a topographic (elevation) map describe lines of approximately equal gravitational potential energy per unit mass (gravitational equipotential). As the distance between two different isolines decreases, the steepness of the surface increases. [Contour lines on topographic maps are useful teaching tools for introducing the concept of equipotential lines. Students are encouraged to use the analogy in their answers when explaining gravitational and electrical potential and potential differences.]

Essential Knowledge 2.E.2: Isolines in a region where an electric field exists represent lines of equal electric potential, referred to as equipotential lines.

Essential Knowledge 2.E.3: The average value of the electric field in a region equals the change in electric potential across that region divided by the change in position (displacement) in the relevant direction.

### **BIG IDEA 3: THE INTERACTIONS OF AN OBJECT WITH OTHER OBJECTS CAN BE DESCRIBED BY FORCES.**

**Enduring Understanding 3.A:** All forces share certain common characteristics when considered by observers in inertial reference frames.

Essential Knowledge 3.A.2: Forces are described by vectors.

Essential Knowledge 3.A.3: A force exerted on an object is always due to the interaction of that object with another object.

Essential Knowledge 3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**Enduring Understanding 3.B:** Classically, the acceleration of an object interacting with other objects can be predicted by using  $\rho$   $\rho$  a  $F$   $m = \Sigma$  .

Essential Knowledge 3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.

Essential Knowledge 3.B.2: Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.

**Enduring Understanding 3.C:** At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.

Essential Knowledge 3.C.2: Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.

Essential Knowledge 3.C.3: A magnetic force results from the interaction of a moving charged object or a magnet with other moving charged objects or another magnet.

Essential Knowledge 3.C.4: Contact forces result from the interaction of one object touching another object, and they arise from interatomic electric forces. These forces include tension, friction, normal, spring (Physics 1), and buoyant (Physics 2).

**Enduring Understanding 3.G:** Certain types of forces are considered fundamental.

Essential Knowledge 3.G.1: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.

Essential Knowledge 3.G.2: Electromagnetic forces are exerted at all scales and can dominate at the human scale.

Essential Knowledge 3.G.3: The strong force is exerted at nuclear scales and dominates the interactions of nucleons.

#### **BIG IDEA 4: INTERACTIONS BETWEEN SYSTEMS CAN RESULT IN CHANGES IN THOSE SYSTEMS.**

**Enduring Understanding 4.C:** Interactions with other objects or systems can change the total energy of a system.

Essential Knowledge 4.C.3: Energy is transferred spontaneously from a higher temperature system to a lower temperature system. The process through which energy is transferred between systems at different temperatures is called heat.

Essential Knowledge 4.C.4: Mass can be converted into energy and energy can be converted into mass.

**Enduring Understanding 4.E:** The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.

Essential Knowledge 4.E.1: The magnetic properties of some materials can be affected by magnetic fields at the system. Students should focus on the underlying concepts and not the use of the vocabulary.

Essential Knowledge 4.E.2: Changing magnetic flux induces an electric field that can establish an induced emf in a system.

Essential Knowledge 4.E.3: The charge distribution in a system can be altered by the effects of electric forces produced by a charged object.



## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

- Essential Knowledge 4.E.4: The resistance of a resistor, and the capacitance of a capacitor, can be understood from the basic properties of electric fields and forces, as well as the properties of materials and their geometry.
- Essential Knowledge 4.E.5: The values of currents and electric potential differences in an electric circuit are determined by the properties and arrangement of the individual circuit elements such as sources of emf, resistors, and capacitors.

#### **BIG IDEA 5: CHANGES THAT OCCUR AS A RESULT OF INTERACTIONS ARE CONSTRAINED BY CONSERVATION LAWS.**

##### **Enduring Understanding 5.B: The energy of a system is conserved.**

- Essential Knowledge 5.B.2: A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy. [Physics 1: includes mass–spring oscillators and simple pendulums. Physics 2: includes charged object in electric fields and examining changes in internal energy with changes in configuration.].
- Essential Knowledge 5.B.4: The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.
- Essential Knowledge 5.B.5: Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system. [A piston filled with gas getting compressed or expanded is treated in Physics 2 as a part of thermodynamics.].
- Essential Knowledge 5.B.6: Energy can be transferred by thermal processes involving differences in temperature; the amount of energy transferred in this process of transfer is called heat.
- Essential Knowledge 5.B.7: The first law of thermodynamics is a specific case of the law of conservation of energy involving the internal energy of a system and the possible transfer of energy through work and/or heat. Examples should include P–V diagrams — isovolumetric process, isothermal process, isobaric process, adiabatic process. No calculations of heat or internal energy from temperature change; and in this course, examples of these relationships are qualitative and/or semi–quantitative.
- Essential Knowledge 5.B.8: Energy transfer occurs when photons are absorbed or emitted, for example, by atoms or nuclei.
- Essential Knowledge 5.B.9: Kirchhoff's loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff's laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors.
- Essential Knowledge 5.B.10: Bernoulli's equation describes the conservation of energy in fluid flow.
- Essential Knowledge 5.B.11: Beyond the classical approximation, mass is actually part of the internal energy of an object or system with  $E = mc^2$ .

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

#### **Enduring Understanding 5.C: The electric charge of a system is conserved.**

- Essential Knowledge 5.C.1: Electric charge is conserved in nuclear and elementary particle reactions, even when elementary particles are produced or destroyed. Examples should include equations representing nuclear decay.
- Essential Knowledge 5.C.2: The exchange of electric charges among a set of objects in a system conserves electric charge.
- Essential Knowledge 5.C.3: Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady-state situations. For circuits with capacitors, situations should be limited to open circuit, just after circuit is closed, and a long time after the circuit is closed.]

#### **Enduring Understanding 5.D: The linear momentum of a system is conserved.**

- Essential Knowledge 5.D.1: In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.
- Essential Knowledge 5.D.2: In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.
- Essential Knowledge 5.D.3: The velocity of the center of mass of the system cannot be changed by an interaction within the system. [Physics 1: includes no calculations of centers of mass; the equation is not provided until Physics 2. However, without doing calculations, Physics 1 students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or two spheres of equal mass.]

#### **Enduring Understanding 5.F: Classically, the mass of a system is conserved.**

- Essential Knowledge 5.F.1: The continuity equation describes conservation of mass flow rate in fluids. Examples should include volume rate of flow, mass flow rate.

#### **Enduring Understanding 5.G: Nucleon number is conserved.**

- Essential Knowledge 5.G.1: The possible nuclear reactions are constrained by the law of conservation of nucleon number.

### **BIG IDEA 6: WAVES CAN TRANSFER ENERGY AND MOMENTUM FROM ONE LOCATION TO ANOTHER WITHOUT THE PERMANENT TRANSFER OF MASS AND SERVE AS A MATHEMATICAL MODEL FOR THE DESCRIPTION OF OTHER PHENOMENA.**

#### **Enduring Understanding 6.A: A wave is a traveling disturbance that transfers energy and momentum.**

- Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

Essential Knowledge 6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum.

**Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.**

Essential Knowledge 6.B.3: A simple wave can be described by an equation involving one sine or cosine function involving the wavelength, amplitude, and frequency of the wave.

**Enduring Understanding 6.C: Only waves exhibit interference and diffraction.**

Essential Knowledge 6.C.1: When two waves cross, they travel through each other; they do not bounce off each other. Where the waves overlap, the resulting displacement can be determined by adding the displacements of the two waves. This is called superposition.

Essential Knowledge 6.C.2: When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed.

Essential Knowledge 6.C.3: When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples should include monochromatic double-slit interference.

Essential Knowledge 6.C.4: When waves pass by an edge, they can diffract into the “shadow region” behind the edge. Examples should include hearing around corners, but not seeing around them, and water waves bending around obstacles.

**Enduring Understanding 6.E: The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.**

Essential Knowledge 6.E.1: When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed. (Qualitative understanding only.)

Essential Knowledge 6.E.2: When light hits a smooth reflecting surface at an angle, it reflects at the same angle on the other side of the line perpendicular to the surface (specular reflection); and this law of reflection accounts for the size and location of images seen in plane mirrors.

Essential Knowledge 6.E.3: When light travels across a boundary from one transparent material to another, the speed of propagation changes. At a non-normal incident angle, the path of the light ray bends closer to the perpendicular in the optically slower substance. This is called refraction.

Essential Knowledge 6.E.4: The reflection of light from surfaces can be used to form images.

Essential Knowledge 6.E.5: The refraction of light as it travels from one transparent medium to another can be used to form images.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**Enduring Understanding 6.F: Electromagnetic radiation can be modeled as waves or as fundamental particles.**

- Essential Knowledge 6.F.1: Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves.
- Essential Knowledge 6.F.2: Electromagnetic waves can transmit energy through a medium and through a vacuum.
- Essential Knowledge 6.F.3: Photons are individual energy packets of electromagnetic waves, with  $E_{\text{photon}} = hf$ , where  $h$  is Planck's constant and  $f$  is the frequency of the associated light wave.
- Essential Knowledge 6.F.4: The nature of light requires that different models of light are most appropriate at different scales.

**Enduring Understanding 6.G: All matter can be modeled as waves or as particles.**

- Essential Knowledge 6.G.1: Under certain regimes of energy or distance, matter can be modeled as a classical particle.
- Essential Knowledge 6.G.2: Under certain regimes of energy or distance, matter can be modeled as a wave. The behavior in these regimes is described by quantum mechanics.

***BIG IDEA 7: THE MATHEMATICS OF PROBABILITY CAN BE USED TO DESCRIBE THE BEHAVIOR OF COMPLEX SYSTEMS AND TO INTERPRET THE BEHAVIOR OF QUANTUM MECHANICAL SYSTEMS.***

**Enduring Understanding 7.A: The properties of an ideal gas can be explained in terms of a small number of macroscopic variables including temperature and pressure.**

- Essential Knowledge 7.A.1: The pressure of a system determines the force that the system exerts on the walls of its container and is a measure of the average change in the momentum or impulse of the molecules colliding with the walls of the container. The pressure also exists inside the system itself, not just at the walls of the container.
- Essential Knowledge 7.A.2: The temperature of a system characterizes the average kinetic energy of its molecules.
- Essential Knowledge 7.A.3: In an ideal gas, the macroscopic (average) pressure ( $P$ ), temperature ( $T$ ), and volume ( $V$ ), are related by the equation  $PV = Nrt$ .

**Enduring Understanding 7.B: The tendency of isolated systems to move toward states with higher disorder is described by probability.**

- Essential Knowledge 7.B.1: The approach to thermal equilibrium is a probability process.
- Essential Knowledge 7.B.2: The second law of thermodynamics describes the change in entropy for reversible and irreversible processes. Only a qualitative treatment is considered in this course.

## AP PHYSICS III – H

### BIG IDEAS, ENDURING UNDERSTANDING AND ESSENTIAL KNOWLEDGE

**Enduring Understanding 7.C:** At the quantum scale, matter is described by a wave function, which leads to a probabilistic description of the microscopic world.

- Essential Knowledge 7.C.1: The probabilistic description of matter is modeled by a wave function, which can be assigned to an object and used to describe its motion and interactions. The absolute value of the wave function is related to the probability of finding a particle in some spatial region. (Qualitative treatment only, using graphical analysis.)
- Essential Knowledge 7.C.2: The allowed states for an electron in an atom can be calculated from the wave model of an electron.
- Essential Knowledge 7.C.3: The spontaneous radioactive decay of an individual nucleus is described by probability.
- Essential Knowledge 7.C.4: Photon emission and absorption processes are described by probability.

### LEARNING OBJECTIVES

- 1.A.2.1 The student is able to construct representations of the differences between a fundamental particle and a system composed of fundamental particles and to relate this to the properties and scales of the systems being investigated.
- 1.A.4.1 The student is able to construct representations of the energy-level structure of an electron in an atom and to relate this to the properties and scales of the systems being investigated.
- 1.A.5.2 The student is able to construct representations of how the properties of a system are determined by the interactions of its constituent substructures.
- 1.B.1.1 The student is able to make claims about natural phenomena based on conservation of electric charge.
- 1.B.1.2 The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
- 1.B.2.1 The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.
- 1.B.2.2 The student is able to make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes.
- 1.B.2.3 The student is able to challenge claims that polarization of electric charge or separation of charge must result in a net charge on the object.
- 1.B.3.1 The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated.
- 1.C.4.1 The student is able to articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass-energy.
- 1.D.1.1 The student is able to explain why classical mechanics cannot describe all properties of objects by articulating the reasons that classical mechanics must be refined and an alternative explanation developed when classical particles display wave properties.
- 1.D.3.1 The student is able to articulate the reasons that classical mechanics must be replaced by special relativity to describe the experimental results and theoretical predictions that show that the properties of space and time are not absolute.
- 1.E.1.1 The student is able to predict the densities, differences in densities, or changes in densities under different conditions for natural phenomena and design an investigation to verify the prediction.
- 1.E.1.2 The student is able to select from experimental data the information necessary to determine the density of an object and/or compare densities of several objects.

## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 1.E.2.1 The student is able to choose and justify the selection of data needed to determine resistivity for a given material.
- 1.E.3.1 The student is able to design an experiment and analyze data from it to examine thermal conductivity.
- 2.C.1.1 The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge  $q$  placed in an electric field  $E$  using the mathematical model of the relation between an electric force and an electric field:  $F=qE$ .
- 2.C.1.2 The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities.
- 2.C.2.1 The student is able to qualitatively and semi-quantitatively apply the vector relationship between the electric field and the net electric charge creating that field.
- 2.C.3.1 The student is able to explain the inverse square dependence of the electric field surrounding a spherically symmetric electrically charged object.
- 2.C.4.1 The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi-quantitative arguments based on vector addition of fields due to each point source.
- 2.C.4.2 The student is able to apply mathematical routines to determine the magnitude and direction of the electric field at specified points in the vicinity of a small set (2–4) of point charges, and express the results in terms of magnitude and direction of the field in a visual representation by drawing field vectors of appropriate length and direction at the specified points.
- 2.C.5.1 The student is able to create representations of the magnitude and direction of the electric field at various distances (small compared to plate size) from two electrically charged plates of equal magnitude and opposite signs, and is able to recognize that the assumption of uniform field is not appropriate near edges of plates.
- 2.C.5.2 The student is able to calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation.
- 2.C.5.3 The student is able to represent the motion of an electrically charged particle in the uniform field between two oppositely charged plates and express the connection of this motion to projectile motion of an object with mass in the Earth’s gravitational field.
- 2.D.1.1 The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field.
- 2.D.2.1 The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires.
- 2.D.3.1 The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet.
- 2.D.4.1 The student is able to use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material.
- 2.E.1.1 The student is able to construct or interpret visual representations of the isolines of equal gravitational potential energy per unit mass and refer to each line as a gravitational equipotential.
- 2.E.2.1 The student is able to determine the structure of isolines of electric potential by constructing them in a given electric field.

## AP PHYSICS III – H LEARNING OBJECTIVES

- 2.E.2.2 The student is able to predict the structure of isolines of electric potential by constructing them in a given electric field and make connections between these isolines and those found in a gravitational field.
- 2.E.2.3 The student is able to qualitatively use the concept of isolines to construct isolines of electric potential in an electric field and determine the effect of that field on electrically charged objects.
- 2.E.3.1 The student is able to apply mathematical routines to calculate the average value of the magnitude of the electric field in a region from a description of the electric potential in that region using the displacement along the line on which the difference in potential is evaluated.
- 2.E.3.2 The student is able to apply the concept of the isoline representation of electric potential for a given electric charge distribution to predict the average value of the electric field in the region.
- 3.A.2.1 The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
- 3.A.3.1 The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.
- 3.A.3.2 The student is able to challenge a claim that an object can exert a force on itself.
- 3.A.3.3 The student is able to describe a force as an interaction between two objects and identify both objects for any force.
- 3.A.3.4 The student is able to make claims about the force on an object due to the presence of other objects with the same property: mass, electric charge.
- 3.A.4.1 The student is able to construct explanations of physical situations involving the interaction of bodies using Newton’s third law and the representation of action-reaction pairs of forces.
- 3.A.4.2 The student is able to use Newton’s third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.
- 3.A.4.3 The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton’s third law to identify forces.
- 3.B.1.3 The student is able to re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object.
- 3.B.1.4 The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton’s second law in a variety of physical situations.
- 3.B.2.1 The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.
- 3.C.2.1 The student is able to use Coulomb’s law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.
- 3.C.2.2 The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.
- 3.C.2.3 The student is able to use mathematics to describe the electric force that results from the interaction of several separated point charges (generally 2 to 4 point charges, though more are permitted in situations of high symmetry).
- 3.C.3.1 The student is able to use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current-carrying conductor.

## AP PHYSICS III – H LEARNING OBJECTIVES

- 3.C.3.2 The student is able to plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion.
- 3.C.4.1 The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.
- 3.C.4.2 The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.
- 3.G.1.2 The student is able to connect the strength of the gravitational force between two objects to the spatial scale of the situation and the masses of the objects involved and compare that strength to other types of forces.
- 3.G.2.1 The student is able to connect the strength of electromagnetic forces with the spatial scale of the situation, the magnitude of the electric charges, and the motion of the electrically charged objects involved.
- 3.G.3.1 The student is able to identify the strong force as the force that is responsible for holding the nucleus together.
- 4.C.3.1 The student is able to make predictions about the direction of energy transfer due to temperature differences based on interactions at the microscopic level.
- 4.C.4.1 The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.
- 4.E.1.1 The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.
- 4.E.2.1 The student is able to construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux through an area defined by a current loop (i.e., a simple microphone or generator) or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area.
- 4.E.3.1 The student is able to make predictions about the redistribution of charge during charging by friction, conduction, and induction.
- 4.E.3.2 The student is able to make predictions about the redistribution of charge caused by the electric field due to other systems, resulting in charged or polarized objects.
- 4.E.3.3 The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors.
- 4.E.3.4 The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors that predicts charge distribution in processes involving induction or conduction.
- 4.E.3.5 The student is able to explain and/or analyze the results of experiments in which electric charge rearrangement occurs by electrostatic induction, or is able to refine a scientific question relating to such an experiment by identifying anomalies in a data set or procedure.
- 4.E.4.1 The student is able to make predictions about the properties of resistors and/or capacitors when placed in a simple circuit based on the geometry of the circuit element and supported by scientific theories and mathematical relationships.
- 4.E.4.2 The student is able to design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors.
- 4.E.4.3 The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors.



## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 4.E.5.1 The student is able to make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.
- 4.E.5.2 The student is able to make and justify a qualitative prediction of the effect of a change in values or arrangements of one or two circuit elements on currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.
- 4.E.5.3 The student is able to plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors.
- 5.B.2.1 The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system.
- 5.B.4.1 The student is able to describe and make predictions about the internal energy of systems.
- 5.B.4.2 The student is able to calculate changes in kinetic energy and potential energy of a system using information from representations of that system.
- 5.B.5.4 The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy).
- 5.B.5.5 The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance.
- 5.B.5.6 The student is able to design an experiment and analyze graphical data in which interpretations of the area under a pressure-volume curve are needed to determine the work done on or by the object or system.
- 5.B.6.1 The student is able to describe the models that represent processes by which energy can be transferred between a system and its environment because of differences in temperature: conduction, convection, and radiation.
- 5.B.7.1 The student is able to predict qualitative changes in the internal energy of a thermodynamic system involving transfer of energy due to heat or work done and justify those predictions in terms of conservation of energy principles.
- 5.B.7.2 The student is able to create a plot of pressure versus volume for a thermodynamic process from given data.
- 5.B.7.3 The student is able to use a plot of pressure versus volume for a thermodynamic process to make calculations of internal energy changes, heat, or work, based upon conservation of energy principles (i.e., the first law of thermodynamics).
- 5.B.8.1 The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.
- 5.B.9.4 The student is able to analyze experimental data including an analysis of experimental uncertainty that will demonstrate the validity of Kirchhoff's loop rule.
- 5.B.9.5 The student is able to use conservation of energy principles (Kirchhoff's loop rule) to describe and make predictions regarding electrical potential difference, charge, and current in steady-state circuits composed of various combinations of resistors and capacitors.
- 5.B.9.6 The student is able to mathematically express the changes in electric potential energy of a loop in a multiloop electrical circuit and justify this expression using the principle of the conservation of energy.

## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 5.B.9.7 The student is able to refine and analyze a scientific question for an experiment using Kirchhoff’s loop rule for circuits that includes determination of internal resistance of the battery and analysis of a nonohmic resistor.
- 5.B.9.8 The student is able to translate between graphical and symbolic representations of experimental data describing relationships among power, current, and potential difference across a resistor.
- 5.B.10.1 The student is able to use Bernoulli’s equation to make calculations related to a moving fluid.
- 5.B.10.2 The student is able to use Bernoulli’s equation and/or the relationship between force and pressure to make calculations related to a moving fluid.
- 5.B.10.3 The student is able to use Bernoulli’s equation and the continuity equation to make calculations related to a moving fluid.
- 5.B.10.4 The student is able to construct an explanation of Bernoulli’s equation in terms of the conservation of energy.
- 5.B.11.1 The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation  $E = mc^2$  to make a related calculation.
- 5.C.1.1 The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge.
- 5.C.2.1 The student is able to predict electric charges on objects within a system by application of the principle of charge conservation within a system.
- 5.C.2.2 The student is able to design a plan to collect data on the electrical charging of objects and electric charge induction on neutral objects and qualitatively analyze that data.
- 5.C.2.3 The student is able to justify the selection of data relevant to an investigation of the electrical charging of objects and electric charge induction on neutral objects.
- 5.C.3.4 The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff’s junction rule and relate the rule to the law of charge conservation.
- 5.C.3.5 The student is able to determine missing values and direction of electric current in branches of a circuit with resistors and NO capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.
- 5.C.3.6 The student is able to determine missing values and direction of electric current in branches of a circuit with both resistors and capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.
- 5.C.3.7 The student is able to determine missing values, direction of electric current, charge of capacitors at steady state, and potential differences within a circuit with resistors and capacitors from values and directions of current in other branches of the circuit.
- 5.D.1.6 The student is able to make predictions of the dynamical properties of a system undergoing a collision by application of the principle of linear momentum conservation and the principle of the conservation of energy in situations in which an elastic collision may also be assumed.
- 5.D.1.7 The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values.
- 5.D.2.5 The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values.
- 5.D.2.6 The student is able to apply the conservation of linear momentum to an isolated system of objects involved in an inelastic collision.

## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 5.D.3.2 The student is able to make predictions about the velocity of the center of mass for interactions within a defined one-dimensional system.
- 5.D.3.3 The student is able to make predictions about the velocity of the center of mass for interactions within a defined two-dimensional system.
- 5.F.1.1 The student is able to make calculations of quantities related to flow of a fluid, using mass conservation principles (the continuity equation).
- 5.G.1.1 The student is able to apply conservation of nucleon number and conservation of electric charge to make predictions about nuclear reactions and decays such as fission, fusion, alpha decay, beta decay, or gamma decay.
- 6.A.1.2 The student is able to describe representations of transverse and longitudinal waves.
- 6.A.1.3 The student is able to analyze data (or a visual representation) to identify patterns that indicate that a particular wave is polarized and construct an explanation of the fact that the wave must have a vibration perpendicular to the direction of energy propagation.
- 6.A.2.2 The student is able to contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation.
- 6.B.3.1 The student is able to construct an equation relating the wavelength and amplitude of a wave from a graphical representation of the electric or magnetic field value as a function of position at a given time instant and vice versa, or construct an equation relating the frequency or period and amplitude of a wave from a graphical representation of the electric or magnetic field value at a given position as a function of time and vice versa.
- 6.C.1.1 The student is able to make claims and predictions about the net disturbance that occurs when two waves overlap. Examples should include standing waves.
- 6.C.1.2 The student is able to construct representations to graphically analyze situations in which two waves overlap over time using the principle of superposition.
- 6.C.2.1 The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening and to qualitatively apply the wave model to quantities that describe the generation of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave.
- 6.C.3.1 The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small, but larger than the wavelength.
- 6.C.4.1 The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light.
- 6.E.1.1 The student is able to make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed.
- 6.E.2.1 The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.
- 6.E.3.1 The student is able to describe models of light traveling across a boundary from one transparent material to another when the speed of propagation changes, causing a change in the path of the light ray at the boundary of the two media.
- 6.E.3.2 The student is able to plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell's law).
- 6.E.3.3 The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation.

## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 6.E.4.1 The student is able to plan data collection strategies and perform data analysis and evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors.
- 6.E.4.2 The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces.
- 6.E.5.1 The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses.
- 6.E.5.2 The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses.
- 6.F.1.1 The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation.
- 6.F.2.1 The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present.
- 6.F.3.1 The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect.
- 6.F.4.1 The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter.
- 6.G.1.1 The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate.
- 6.G.2.1 The student is able to articulate the evidence supporting the claim that a wave model of matter is appropriate to explain the diffraction of matter interacting with a crystal, given conditions where a particle of matter has momentum corresponding to a de Broglie wavelength smaller than the separation between adjacent atoms in the crystal.
- 6.G.2.2 The student is able to predict the dependence of major features of a diffraction pattern (e.g., spacing between interference maxima) based upon the particle speed and de Broglie wavelength of electrons in an electron beam interacting with a crystal. (de Broglie wavelength need not be given, so students may need to obtain it.)
- 7.A.1.1 The student is able to make claims about how the pressure of an ideal gas is connected to the force exerted by molecules on the walls of the container, and how changes in pressure affect the thermal equilibrium of the system.
- 7.A.1.2 Treating a gas molecule as an object (i.e., ignoring its internal structure), the student is able to analyze qualitatively the collisions with a container wall and determine the cause of pressure and at thermal equilibrium to quantitatively calculate the pressure, force, or area for a thermodynamic problem given two of the variables.
- 7.A.2.1 The student is able to qualitatively connect the average of all kinetic energies of molecules in a system to the temperature of the system.
- 7.A.2.2 The student is able to connect the statistical distribution of microscopic kinetic energies of molecules to the macroscopic temperature of the system and to relate this to thermodynamic processes.
- 7.A.3.1 The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero.
- 7.A.3.2 The student is able to design a plan for collecting data to determine the relationships between pressure, volume, and temperature, and amount of an ideal gas, and to refine a scientific question concerning a proposed incorrect relationship between the variables.

## AP PHYSICS III – H

### LEARNING OBJECTIVES

- 7.A.3.3 The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law  $PV = nRT$ .
- 7.B.1.1 The student is able to construct an explanation, based on atomic-scale interactions and probability, of how a system approaches thermal equilibrium when energy is transferred to it or from it in a thermal process.
- 7.B.2.1 The student is able to connect qualitatively the second law of thermodynamics in terms of the state function called entropy and how it (entropy) behaves in reversible and irreversible processes.
- 7.C.1.1 The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region.
- 7.C.2.1 The student is able to use a standing wave model in which an electron orbit circumference is an integer multiple of the de Broglie wavelength to give a qualitative explanation that accounts for the existence of specific allowed energy states of an electron in an atom.
- 7.C.3.1 The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay.
- 7.C.4.1 The student is able to construct or interpret representations of transitions between atomic energy states involving the emission and absorption of photons.

## AP PHYSICS III – H

### UNIT 1: ELECTROSTATICS

#### Big Ideas:

- 1.B Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.
- 2.C An electric field is caused by an object with electric charge.
- 2.E Physicists often construct a map of isolines connecting points of equal value for some quantity related to a field and use these maps to help visualize the field.
- 3.A All forces share certain common characteristics when considered by observers in inertial reference frames.
- 3.B Classically, the acceleration of an object interacting with other objects can be predicted by using  $\rho \rho a F m = \Sigma$ .
- 3.C At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 3.G Certain types of forces are considered fundamental.
- 4.E The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.
- 5.C The electric charge of a system is conserved.

#### Essential Questions

*How can the charge model be used to explain electric phenomena?*

*How can electric charge interactions be explained with an electric field model?*

*How can physical quantities such as electric field and electric potential be defined operationally?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.</li> <li>▪ The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.</li> <li>▪ The magnitude of the electric force <math>F</math> exerted on an object with electric charge <math>q</math> by an electric field <math>E</math> is <math>F = qE</math>. The direction of the force is determined by the direction of the field and the sign of the charge, with positively charged objects</li> </ul>	<p>To get students thinking about charges, conservation of electrical charge, and the basis of natural phenomena involving static electricity, a Van de Graaff generator is utilized for basic demonstrations involving a variety of objects. A demonstration using a small paper clip “lightning rod” through a pie plate is used to show that lightning rods do more to prevent lightning than to attract and ground it. The demonstrations are followed by class discussion. Then students write a research paper about lightning and lightning safety. Papers should include discussion about the conservation of electric charge and various methods for separating charges, the elementary or fundamental particles of charge and their</p>	<ul style="list-style-type: none"> <li>▪ The student is able to make claims about natural phenomena based on conservation of electric charge.</li> <li>▪ The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.</li> <li>▪ The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated.</li> <li>▪ The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge <math>q</math> placed in</li> </ul>

**AP PHYSICS III – H**  
**UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>accelerating in the direction of the field and negatively charged objects accelerating in the direction opposite the field. This should include a vector field map for positive point charges, negative point charges, spherically symmetric charge distribution, and uniformly charged parallel plates.</p> <ul style="list-style-type: none"> <li>▪ The electric field outside a spherically symmetric charged object is radial, and its magnitude varies as the inverse square of the radial distance from the center of that object. Electric field lines are not in the curriculum. Students will be expected to rely only on the rough intuitive sense underlying field lines, wherein the field is viewed as analogous to something emanating uniformly from a source.</li> <li>▪ The electric field around dipoles and other systems of electrically charged objects (that can be modeled as point objects) is found by vector addition of the field of each individual object. Electric dipoles are treated qualitatively in this course as a teaching analogy to facilitate student understanding of magnetic dipoles.</li> <li>▪ Between two oppositely charged parallel plates with uniformly</li> </ul>	<p>quantities/qualities, and how we know there can be no smaller carrier of charge</p> <p>Working in small groups, students use rods, cloths of various materials, and an electroscope to draw conclusions about various kinds of interactions between electric charges, as well as to discover the charges imparted to different materials by rubbing with different cloths. Students must first be shown how the electroscope works and how to charge materials through rubbing, but then they may be left to discover different combinations and outcomes on their own. Students then produce a final written analysis of what they observed and the physical basis for it</p>	<p>an electric field <math>E</math> using the mathematical model of the relation between an electric force and an electric field: <math>F=qE</math></p> <ul style="list-style-type: none"> <li>▪ The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities.</li> <li>▪ The student is able to qualitatively and semi-quantitatively apply the vector relationship between the electric field and the net electric charge creating that field.</li> <li>▪ The student is able to explain the inverse square dependence of the electric field surrounding a spherically symmetric electrically charged object.</li> <li>▪ The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi-quantitative arguments based on vector addition of fields due to each point source.</li> <li>▪ The student is able to apply mathematical routines to determine the magnitude and direction of the electric field at specified points in the vicinity of a small set (2–4) of point charges, and express the results in terms of magnitude and direction of the field in a visual representation by drawing field</li> </ul>

**AP PHYSICS III – H**  
**UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>distributed electric charge, at points far from the edges of the plates, the electric field is perpendicular to the plates and is constant in both magnitude and direction.</p> <ul style="list-style-type: none"> <li>▪ Isolines on a topographic (elevation) map describe lines of approximately equal gravitational potential energy per unit mass (gravitational equipotential). As the distance between two different isolines decreases, the steepness of the surface increases. [Contour lines on topographic maps are useful teaching tools for introducing the concept of equipotential lines. Students are encouraged to use the analogy in their answers when explaining gravitational and electrical potential and potential differences.]</li> <li>▪ Isolines in a region where an electric field exists represent lines of equal electric potential, referred to as equipotential lines.</li> <li>▪ The average value of the electric field in a region equals the change in electric potential across that region divided by the change in position (displacement) in the relevant direction.</li> <li>▪ Forces are described by vectors.</li> <li>▪ A force exerted on an object is</li> </ul>		<p>vectors of appropriate length and direction at the specified points.</p> <ul style="list-style-type: none"> <li>▪ The student is able to create representations of the magnitude and direction of the electric field at various distances (small compared to plate size) from two electrically charged plates of equal magnitude and opposite signs, and is able to recognize that the assumption of uniform field is not appropriate near edges of plates.</li> <li>▪ The student is able to calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation.</li> <li>▪ The student is able to represent the motion of an electrically charged particle in the uniform field between two oppositely charged plates and express the connection of this motion to projectile motion of an object with mass in the Earth’s gravitational field.</li> <li>▪ The student is able to construct or interpret visual representations of the isolines of equal gravitational potential energy per unit mass and refer to each line as a gravitational equipotential.</li> <li>▪ The student is able to determine the structure of isolines of electric potential by constructing them in a given electric field.</li> <li>▪ The student is able to predict the structure of isolines of electric potential by</li> </ul>



**AP PHYSICS III – H  
UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>always due to the interaction of that object with another object.</p> <ul style="list-style-type: none"> <li>▪ If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.</li> <li>▪ If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.</li> <li>▪ Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.</li> <li>▪ Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.</li> <li>▪ Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.</li> <li>▪ Electromagnetic forces are exerted at all scales and can dominate at the human scale.</li> <li>▪ Changing magnetic flux induces an electric field that can establish an induced emf in a system.</li> <li>▪ The charge distribution in a system can be altered by the effects of electric forces produced by a charged object.</li> </ul>		<p>constructing them in a given electric field and make connections between these isolines and those found in a gravitational field.</p> <ul style="list-style-type: none"> <li>▪ The student is able to qualitatively use the concept of isolines to construct isolines of electric potential in an electric field and determine the effect of that field on electrically charged objects.</li> <li>▪ The student is able to apply mathematical routines to calculate the average value of the magnitude of the electric field in a region from a description of the electric potential in that region using the displacement along the line on which the difference in potential is evaluated.</li> <li>▪ The student is able to apply the concept of the isoline representation of electric potential for a given electric charge distribution to predict the average value of the electric field in the region.</li> <li>▪ The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.</li> <li>▪ The student is able to challenge a claim that an object can exert a force on itself.</li> <li>▪ The student is able to describe a force as an interaction between two objects and identify both objects for any force.</li> <li>▪ The student is able to make claims about the force on an object due to the presence of</li> </ul>

**AP PHYSICS III – H**  
**UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The exchange of electric charges among a set of objects in a system conserves electric charge.</li> <li>▪ Kirchhoff’s junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady–state situations. For circuits with capacitors, situations should be limited to open circuit, just after circuit is closed, and a long time after the circuit is closed.]</li> </ul>		<p>other objects with the same property: mass, electric charge.</p> <ul style="list-style-type: none"> <li>▪ The student is able to construct explanations of physical situations involving the interaction of bodies using Newton’s third law and the representation of action-reaction pairs of forces.</li> <li>▪ The student is able to use Newton’s third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.</li> <li>▪ The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton’s third law to identify forces.</li> <li>▪ The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton’s second law in a variety of physical situations.</li> <li>▪ The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.</li> <li>▪ The student is able to use Coulomb’s law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.</li> <li>▪ The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.</li> </ul>

**AP PHYSICS III – H**  
**UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<ul style="list-style-type: none"> <li>▪ The student is able to use mathematics to describe the electric force that results from the interaction of several separated point charges (generally 2 to 4 point charges, though more are permitted in situations of high symmetry).</li> <li>▪ The student is able to connect the strength of the gravitational force between two objects to the spatial scale of the situation and the masses of the objects involved and compare that strength to other types of forces.</li> <li>▪ The student is able to connect the strength of electromagnetic forces with the spatial scale of the situation, the magnitude of the electric charges, and the motion of the electrically charged objects involved.</li> <li>▪ The student is able to make predictions about the redistribution of charge during charging by friction, conduction, and induction.</li> <li>▪ The student is able to make predictions about the redistribution of charge caused by the electric field due to other systems, resulting in charged or polarized objects.</li> <li>▪ The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors.</li> <li>▪ The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors that predicts charge distribution</li> </ul>

**AP PHYSICS III – H**  
**UNIT 1: ELECTROSTATICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<p>in processes involving induction or conduction.</p> <ul style="list-style-type: none"> <li>▪ The student is able to explain and/or analyze the results of experiments in which electric charge rearrangement occurs by electrostatic induction, or is able to refine a scientific question relating to such an experiment by identifying anomalies in a data set or procedure.</li> <li>▪ The student is able to predict electric charges on objects within a system by application of the principle of charge conservation within a system.</li> <li>▪ The student is able to design a plan to collect data on the electrical charging of objects and electric charge induction on neutral objects and qualitatively analyze that data.</li> <li>▪ The student is able to justify the selection of data relevant to an investigation of the electrical charging of objects and electric charge induction on neutral objects.</li> </ul>

## AP PHYSICS III – H

### UNIT 2: ELECTRIC CURRENTS

#### Big Ideas:

- 1.E Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.
- 4.E The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.
- 5.B The energy of a system is conserved.
- 5.C The electric charge of a system is conserved.

#### Essential Questions

*How can the concepts of resistance and resistivity be used in predicting currents in circuits?*

*How can phenomena occurring in electric circuits be described in terms of physical quantities such as potential difference (voltage), electric current, electric resistance, and electric power?*

*How do conservation laws apply to electric circuits?*

*How is the behavior of an electric circuit determined by the properties and arrangement of the individual circuit elements such as sources of emf, resistors, and capacitors?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Matter has a property called density.</li> <li>▪ The resistance of a resistor, and the capacitance of a capacitor, can be understood from the basic properties of electric fields and forces, as well as the properties of materials and their geometry.</li> <li>▪ The values of currents and electric potential differences in an electric circuit are determined by the properties and arrangement of the individual circuit elements such as sources of emf, resistors, and capacitors.</li> <li>▪ A system with internal structure can have internal energy, and changes in a system's internal</li> </ul>	<p><b>RC Circuit Investigation:</b> Students work in groups of three or four in this two-part lab investigation. The first part of the lab is guided inquiry and consists of an observational experiment in which the students make qualitative descriptions of the charging and discharging of a capacitor. Even though the treatment of this subject is qualitative, students discuss the current-versus-time and charge-versus-time graphs, which demonstrate exponential functions. The second part of this lab is open inquiry. Students design and conduct an experiment to investigate the behavior of resistors in a series-parallel combination with a capacitor in series. Measurements of currents and potential differences are required.</p> <p><b>DC Circuits and Resistors Investigation:</b> In this open-inquiry lab, students work in groups of three</p>	<ul style="list-style-type: none"> <li>▪ The student is able to choose and justify the selection of data needed to determine resistivity for a given material.</li> <li>▪ The student is able to make predictions about the properties of resistors and/or capacitors when placed in a simple circuit based on the geometry of the circuit element and supported by scientific theories and mathematical relationships.</li> <li>▪ The student is able to design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors.</li> <li>▪ The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance</li> </ul>

**AP PHYSICS III – H**  
**UNIT 2: ELECTRIC CURRENTS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>structure can result in changes in internal energy. [Physics 1: includes mass–spring oscillators and simple pendulums. Physics 2: includes charged object in electric fields and examining changes in internal energy with changes in configuration.]</p> <ul style="list-style-type: none"> <li>▪ Kirchhoff’s loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff’s laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors.</li> <li>▪ Kirchhoff’s junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady–state situations. For circuits with capacitors, situations should be limited to open circuit, just after</li> </ul>	<p>or four to design and conduct an experiment to investigate the behavior of resistors in series, parallel, and series–parallel circuits. The lab should include measurements of potential differences and currents. The final report should include explicit application of Kirchhoff’s loop and junction rules.</p> <p><b>DC Circuits and Brightness Investigation:</b> In small groups, students engage in guided-inquiry investigations that explore the concepts of electric circuits and series and parallel connections. The tasks require students to make predictions about the brightness of light bulbs in a circuit when one or two of the light bulbs are removed. Students start with qualitative observations of the brightness of light bulbs connected in series and in parallel.</p>	<p>or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors</p> <ul style="list-style-type: none"> <li>▪ The student is able to make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.</li> <li>▪ The student is able to make and justify a qualitative prediction of the effect of a change in values or arrangements of one or two circuit elements on currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.</li> <li>▪ The student is able to plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors.</li> <li>▪ The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes</li> </ul>

**AP PHYSICS III – H**  
**UNIT 2: ELECTRIC CURRENTS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>circuit is closed, and a long time after the circuit is closed.]</p>		<p>in internal structure because the object is actually a system.</p> <ul style="list-style-type: none"> <li>▪ The student is able to use conservation of energy principles (Kirchhoff’s loop rule) to describe and make predictions regarding electrical potential difference, charge, and current in steady-state circuits composed of various combinations of resistors and capacitors.</li> <li>▪ The student is able to mathematically express the changes in electric potential energy of a loop in a multiloop electrical circuit and justify this expression using the principle of the conservation of energy.</li> <li>▪ The student is able to refine and analyze a scientific question for an experiment using Kirchhoff’s loop rule for circuits that includes determination of internal resistance of the battery and analysis of a nonohmic resistor.</li> <li>▪ The student is able to translate between graphical and symbolic representations of experimental data describing relationships among power, current, and potential difference across a resistor.</li> <li>▪ The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff’s junction rule and relate the rule to the law of charge conservation.</li> <li>▪ The student is able to determine missing values and direction of electric current in branches of a circuit with resistors and NO</li> </ul>

**AP PHYSICS III – H**  
**UNIT 2: ELECTRIC CURRENTS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<p>capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.</p> <ul style="list-style-type: none"> <li>▪ The student is able to determine missing values and direction of electric current in branches of a circuit with both resistors and capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.</li> <li>▪ The student is able to determine missing values, direction of electric current, charge of capacitors at steady state, and potential differences within a circuit with resistors and capacitors from values and directions of current in other branches of the circuit.</li> </ul>



## AP PHYSICS III – H UNIT 3: FLUIDS

### Big Ideas:

- 1.A The internal structure of a system determines many properties of the system.
- 1.E Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.
- 3.C At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 5.B The energy of a system is conserved.
- 5.C The electric charge of a system is conserved.

### Essential Questions

*How are pressure and depth related?*

*How is the buoyant force related to Archimedes' principle?*

*What are the simplifications used in describing ideal fluid flow?*

*How is energy transformed within a system and between a system and the environment?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.</li> <li>▪ Matter has a property called density.</li> <li>▪ Contact forces result from the interaction of one object touching another object, and they arise from interatomic electric forces. These forces include tension, friction,</li> </ul>	<p><b>Archimedes' Principle Investigation:</b> In this open-inquiry lab, students work in pairs to design and implement a data-collection strategy to determine the unknown densities of a liquid and two objects using Archimedes' principle.</p> <p><b>Torricelli's Theorem Investigation:</b> Students design and conduct an experiment using a clear 2 L plastic bottle to determine the exit velocity of a liquid and predict the range attained with holes at varying heights.</p> <p><b>Ideal Fluid Flow:</b> In this Physlet exercise, the students must decide what quantities they should measure in order to identify the animation that shows a possible physical situation for ideal fluid flow</p> <p><b>Water Fountain Investigation:</b> Working in pairs in this guided-inquiry activity, students design and conduct an investigation of a water fountain to determine the following:</p>	<ul style="list-style-type: none"> <li>▪ The student is able to construct representations of how the properties of a system are determined by the interactions of its constituent substructures.</li> <li>▪ The student is able to predict the densities, differences in densities, or changes in densities under different conditions for natural phenomena and design an investigation to verify the prediction.</li> <li>▪ The student is able to select from experimental data the information necessary to determine the density of an object and/or compare densities of several objects.</li> <li>▪ The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.</li> <li>▪ The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and</li> </ul>

**AP PHYSICS III – H  
UNIT 3: FLUIDS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>normal, spring (Physics 1), and buoyant (Physics 2).</p> <ul style="list-style-type: none"> <li>▪ Bernoulli’s equation describes the conservation of energy in fluid flow.</li> <li>▪ The continuity equation describes conservation of mass flow rate in fluids. Examples should include volume rate of flow, mass flow rate.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Exit angle and exit speed of the water</li> <li>▪ Maximum height of water</li> <li>▪ Radius of the fountain’s exit hole</li> <li>▪ Flow volume rate</li> </ul>	<p>that they therefore have certain directions.</p> <ul style="list-style-type: none"> <li>▪ The student is able to use Bernoulli’s equation to make calculations related to a moving fluid.</li> <li>▪ The student is able to use Bernoulli’s equation and/or the relationship between force and pressure to make calculations related to a moving fluid.</li> <li>▪ The student is able to use Bernoulli’s equation and the continuity equation to make calculations related to a moving fluid.</li> <li>▪ The student is able to construct an explanation of Bernoulli’s equation in terms of the conservation of energy.</li> <li>▪ The student is able to make calculations of quantities related to flow of a fluid, using mass conservation principles (the continuity equation).</li> </ul>

## AP PHYSICS III – H

### UNIT 4: MAGNETISM AND INDUCTION

#### Big Ideas:

- 2.C An electric field is caused by an object with electric charge.
- 2.D A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles.
- 3.C At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 4.E The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.

#### Essential Questions

*How is the magnetic field model a mechanism of action-at-a-distance?*

*How does a magnetic field exert a force on moving charges and on electric currents?*

*How is a current induced by a magnetic field, and how is Lenz’s law applied to determine the direction of the induced current?*

*How is the law of electromagnetic induction (Faraday’s law) applied?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The electric field around dipoles and other systems of electrically charged objects (that can be modeled as point objects) is found by vector addition of the field of each individual object. Electric dipoles are treated qualitatively in this course as a teaching analogy to facilitate student understanding of magnetic dipoles.</li> <li>▪ The magnetic field exerts a force on a moving electrically charged object. That magnetic force is perpendicular to the direction of velocity of the object and to the magnetic field and is proportional to the magnitude of the charge, the magnitude of the velocity and the magnitude of the magnetic field. It also depends on the angle between the velocity, and</li> </ul>	<p><b>Electromagnetic Induction:</b> This qualitative guided-inquiry investigation offers students a hands-on opportunity to see how Lenz’s law works. In this lab, students in groups of three or four move a bar magnet in and out of a solenoid and observe the deflection of the galvanometer.</p> <p><b>Magnetic Flux:</b> Working in pairs, students use the “Faraday’s Electromagnetic Lab” simulation to predict the direction of the magnetic field at various locations around five different objects: bar magnet, coil of wire, electromagnet, transformer, and generator. Students gather measurements of the magnitude and direction of the magnetic field and record their observations and measurements</p> <p><b>Magnetic Force on a Current-Carrying Wire Investigation:</b> In this guided-inquiry</p>	<ul style="list-style-type: none"> <li>▪ The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi-quantitative arguments based on vector addition of fields due to each point source.</li> <li>▪ The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field.</li> <li>▪ The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires.</li> <li>▪ The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet.</li> </ul>

**AP PHYSICS III – H**  
**UNIT 4: MAGNETISM AND INDUCTION**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>the magnetic field vectors. Treatment is quantitative for angles of 0°, 90°, or 180° and qualitative for other angles.</p> <ul style="list-style-type: none"> <li>▪ The magnetic field vectors around a straight wire that carries electric current are tangent to concentric circles centered on that wire. The field has no component toward the current-carrying wire.</li> <li>▪ A magnetic dipole placed in a magnetic field, such as the ones created by a magnet or the Earth, will tend to align with the magnetic field vector.</li> <li>▪ Ferromagnetic materials contain magnetic domains that are themselves magnets.</li> <li>▪ A magnetic force results from the interaction of a moving charged object or a magnet with other moving charged objects or another magnet.</li> <li>▪ The magnetic properties of some materials can be affected by magnetic fields at the system. Students should focus on the underlying concepts and not the use of the vocabulary.</li> <li>▪ Changing magnetic flux induces an electric field that can establish an induced emf in a system.</li> </ul>	<p>investigation, students working in teams of three or four design and conduct an experiment to determine the magnitude and direction of the magnetic force exerted on a current-carrying wire.</p> <p><b>Earth’s Magnetic Field Investigation:</b> In this guided-inquiry investigation, students working in pairs design and conduct an experiment using a solenoid and a compass to measure the horizontal component of Earth’s magnetic field. Students then compare their experimental value to the accepted value of the horizontal component of Earth’s magnetic field.</p>	<ul style="list-style-type: none"> <li>▪ The student is able to use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material.</li> <li>▪ The student is able to use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current-carrying conductor.</li> <li>▪ The student is able to plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion.</li> <li>▪ The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.</li> <li>▪ The student is able to construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux through an area defined by a current loop (i.e., a simple microphone or generator) or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area.</li> </ul>

## AP PHYSICS III – H

### UNIT 5: GEOMETRIC OPTICS

#### Big Ideas:

- 6.A A wave is a traveling disturbance that transfers energy and momentum.
- 6.B A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.
- 6.C Only waves exhibit interference and diffraction.
- 6.E The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.
- 6.F Electromagnetic radiation can be modeled as waves or as fundamental particles.

#### Essential Questions

*How are waves' energy transport phenomena?*

*How can wave boundary behavior be used to explain absorption, reflection, and transmission of light?*

*How do the basic optic phenomena of reflection and refraction explain the formation of images by mirrors and lenses?*

*How does light interference demonstrate the wave nature of light?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Waves can propagate via different oscillation modes such as transverse and longitudinal.</li> <li>▪ For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum.</li> <li>▪ A simple wave can be described by an equation involving one sine or cosine function involving the wavelength, amplitude, and frequency of the wave.</li> <li>▪ When two waves cross, they travel through each other; they do not bounce off each other. Where the waves overlap, the resulting</li> </ul>	<p><b>Double-Slit Interference and Diffraction:</b> The students work in groups of three or four to design their own investigations in a guided-inquiry format to achieve the following:</p> <ol style="list-style-type: none"> <li>1. Use a double slit to determine the wavelength of a RED laser.</li> <li>2. Apply the results of the double-slit experiment to predict the location of bright and dark fringes when a GREEN laser is used.</li> <li>3. Determine the spacing in a diffraction grating</li> </ol> <p><b>Thin Lenses Investigation:</b> In a guided-inquiry investigation, students design and implement two separate data-collection strategies to determine the focal length of a converging lens directly and the focal length of a diverging lens by combining it with a converging lens.</p>	<ul style="list-style-type: none"> <li>▪ The student is able to describe representations of transverse and longitudinal waves.</li> <li>▪ The student is able to analyze data (or a visual representation) to identify patterns that indicate that a particular wave is polarized and construct an explanation of the fact that the wave must have a vibration perpendicular to the direction of energy propagation.</li> <li>▪ The student is able to contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation.</li> <li>▪ The student is able to construct an equation relating the wavelength and amplitude of a wave from a graphical representation of the electric or magnetic field value as a function of position at a given time instant and vice versa, or construct an equation relating the</li> </ul>

**AP PHYSICS III – H**  
**UNIT 5: GEOMETRIC OPTICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>displacement can be determined by adding the displacements of the two waves. This is called superposition.</p> <ul style="list-style-type: none"> <li>▪ When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed</li> <li>▪ When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples should include monochromatic double-slit interference.</li> <li>▪ When waves pass by an edge, they can diffract into the “shadow region” behind the edge. Examples should include hearing around corners, but not seeing around them, and water waves bending around obstacles.</li> <li>▪ When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed. (Qualitative understanding only.)</li> <li>▪ When light hits a smooth reflecting surface at an angle, it reflects at the same angle on the other side of the line perpendicular to the surface (specular reflection); and this law of reflection accounts for the size and location of images seen in plane mirrors.</li> </ul>	<p><b>Index of Refraction Investigation:</b> Working with a partner in this guided-inquiry lab, students design and conduct an investigation to determine the index of refraction of an acrylic block. The investigation must involve an analysis of the data plotted on an appropriate graph</p>	<p>frequency or period and amplitude of a wave from a graphical representation of the electric or magnetic field value at a given position as a function of time and vice versa.</p> <ul style="list-style-type: none"> <li>▪ The student is able to make claims and predictions about the net disturbance that occurs when two waves overlap. Examples should include standing waves.</li> <li>▪ The student is able to construct representations to graphically analyze situations in which two waves overlap over time using the principle of superposition.</li> <li>▪ The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening and to qualitatively apply the wave model to quantities that describe the generation of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave.</li> <li>▪ The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small, but larger than the wavelength.</li> <li>▪ The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave</li> </ul>

**AP PHYSICS III – H**  
**UNIT 5: GEOMETRIC OPTICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ When light travels across a boundary from one transparent material to another, the speed of propagation changes. At a non-normal incident angle, the path of the light ray bends closer to the perpendicular in the optically slower substance. This is called refraction.</li> <li>▪ The reflection of light from surfaces can be used to form images.</li> <li>▪ The refraction of light as it travels from one transparent medium to another can be used to form images.</li> <li>▪ Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves</li> <li>▪ Electromagnetic waves can transmit energy through a medium and through a vacuum.</li> </ul>		<p>phenomena, including sound and light.</p> <ul style="list-style-type: none"> <li>▪ The student is able to make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed.</li> <li>▪ The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.</li> <li>▪ The student is able to describe models of light traveling across a boundary from one transparent material to another when the speed of propagation changes, causing a change in the path of the light ray at the boundary of the two media.</li> <li>▪ The student is able to plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell’s law).</li> <li>▪ The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation.</li> </ul>

**AP PHYSICS III – H**  
**UNIT 5: GEOMETRIC OPTICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
		<ul style="list-style-type: none"> <li>▪ The student is able to plan data collection strategies and perform data analysis and evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors.</li> <li>▪ The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces.</li> <li>▪ The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses.</li> <li>▪ The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses.</li> <li>▪ The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation.</li> <li>▪ The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present.</li> </ul>



## AP PHYSICS III – H

### UNIT 6: THERMODYNAMICS

#### Big Ideas:

- 1.A The internal structure of a system determines many properties of the system.
- 1.E Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.
- 4.C Interactions with other objects or systems can change the total energy of a system.
- 5.B The energy of a system is conserved.
- 7.A The properties of an ideal gas can be explained in terms of a small number of macroscopic variables including temperature and pressure.
- 7.B The tendency of isolated systems to move toward states with higher disorder is described by probability.

#### Essential Question

*How are the pressure, volume, and temperature of an ideal gas related and graphically represented?  
 How is energy transferred and transformed?  
 How is the first law of thermodynamics applied to processes undergone by a system?  
 What are the implications of the second law of thermodynamics?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.</li> <li>▪ Matter has a property called thermal conductivity.</li> <li>▪ Energy is transferred spontaneously from a higher temperature system to a lower temperature system. The process through which energy is transferred between systems at different temperatures is called heat.</li> <li>▪ The internal energy of a system</li> </ul>	<p><b>Introduction to P–V Diagrams:</b>            Students read about the first law of thermodynamics in their textbooks prior to class. At the beginning of class, I ask the students a few questions to activate their knowledge of the content. I then use Jim Mooney’s article to guide my presentation about the first law of thermodynamics and P–V diagrams. In pairs, students work through the article’s examples before I present the full solutions.            Link:  <a href="http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/44428.html?type=print">http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/44428.html?type=print</a></p> <p><b>Thermal Conductivity Investigation:</b> In</p>	<ul style="list-style-type: none"> <li>▪ The student is able to construct representations of how the properties of a system are determined by the interactions of its constituent substructures.</li> <li>▪ The student is able to design an experiment and analyze data from it to examine thermal conductivity.</li> <li>▪ The student is able to make predictions about the direction of energy transfer due to temperature differences based on interactions at the microscopic level.</li> <li>▪ The student is able to describe and make predictions about the internal energy of systems.</li> <li>▪ The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance.</li> </ul>

## AP PHYSICS III – H UNIT 6: THERMODYNAMICS

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.</p> <ul style="list-style-type: none"> <li>▪ Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system. [A piston filled with gas getting compressed or expanded is treated in Physics 2 as a part of thermodynamics.]</li> <li>▪ Energy can be transferred by thermal processes involving differences in temperature; the amount of energy transferred in this process of transfer is called heat.</li> <li>▪ The first law of thermodynamics is a specific case of the law of conservation of energy involving the internal energy of a system and the possible transfer of energy through work and/or heat. Examples should include P–V diagrams — isovolumetric process, isothermal process, isobaric process, adiabatic process. No calculations of heat or</li> </ul>	<p>this open-inquiry investigation, the students work in small groups to design and conduct an experiment to determine the thermal conductivity of a material by comparing the difference in temperature across that material to the difference in temperature across a second material of known thermal conductivity.</p> <p>Link: <a href="http://youtu.be/vqDbMEdLiCs">http://youtu.be/vqDbMEdLiCs</a></p> <p><b>Kinetic Theory of Matter:</b> Students are introduced to the kinetic theory of matter by working with a partner on the “Phase Changes” section of the “States of Matter” simulation. By changing the temperature or volume of a container, the students can see how a pressure–temperature diagram responds in real time.</p>	<ul style="list-style-type: none"> <li>▪ The student is able to describe the models that represent processes by which energy can be transferred between a system and its environment because of differences in temperature: conduction, convection, and radiation.</li> <li>▪ The student is able to predict qualitative changes in the internal energy of a thermodynamic system involving transfer of energy due to heat or work done and justify those predictions in terms of conservation of energy principles.</li> <li>▪ The student is able to create a plot of pressure versus volume for a thermodynamic process from given data.</li> <li>▪ The student is able to use a plot of pressure versus volume for a thermodynamic process to make calculations of internal energy changes, heat, or work, based upon conservation of energy principles (i.e., the first law of thermodynamics).</li> <li>▪ The student is able to make claims about how the pressure of an ideal gas is connected to the force exerted by molecules on the walls of the container, and how changes in pressure affect the thermal equilibrium of the system.</li> <li>▪ Treating a gas molecule as an object (i.e., ignoring its internal structure), the student is able to analyze qualitatively the collisions with a container wall and determine the cause of pressure and at thermal equilibrium to quantitatively calculate the pressure, force, or area for a thermodynamic problem given two of the variables.</li> <li>▪ The student is able to qualitatively connect the</li> </ul>

**AP PHYSICS III – H**  
**UNIT 6: THERMODYNAMICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>internal energy from temperature change; and in this course, examples of these relationships are qualitative and/or semi-quantitative.</p> <ul style="list-style-type: none"> <li>▪ The pressure of a system determines the force that the system exerts on the walls of its container and is a measure of the average change in the momentum or impulse of the molecules colliding with the walls of the container. The pressure also exists inside the system itself, not just at the walls of the container.</li> <li>▪ The temperature of a system characterizes the average kinetic energy of its molecules</li> <li>▪ In an ideal gas, the macroscopic (average) pressure (P), temperature (T), and volume (V), are related by the equation <math>PV = Nrt</math>.</li> <li>▪ The approach to thermal equilibrium is a probability process.</li> <li>▪ The second law of thermodynamics describes the change in entropy for reversible and irreversible processes. Only a qualitative treatment is considered in this course.</li> </ul>		<p>average of all kinetic energies of molecules in a system to the temperature of the system.</p> <ul style="list-style-type: none"> <li>▪ The student is able to connect the statistical distribution of microscopic kinetic energies of molecules to the macroscopic temperature of the system and to relate this to thermodynamic processes.</li> <li>▪ The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero.</li> <li>▪ The student is able to design a plan for collecting data to determine the relationships between pressure, volume, and temperature, and amount of an ideal gas, and to refine a scientific question concerning a proposed incorrect relationship between the variables.</li> <li>▪ The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law <math>PV = nRT</math></li> <li>▪ The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law <math>PV = nRT</math></li> <li>▪ The student is able to connect qualitatively the second law of thermodynamics in terms of the state function called entropy and how it (entropy) behaves in reversible and irreversible processes.</li> </ul>

## AP PHYSICS III – H

### UNIT 7: ATOMIC PHYSICS

#### Big Ideas:

- 1.A The internal structure of a system determines many properties of the system.
- 1.C Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
- 1.D Classical mechanics cannot describe all properties of objects.
- 3.G Certain types of forces are considered fundamental.
- 4.C Interactions with other objects or systems can change the total energy of a system.
- 5.B The energy of a system is conserved.
- 5.C The electric charge of a system is conserved.
- 5.D The linear momentum of a system is conserved
- 5.G Nucleon number is conserved.
- 6.F Electromagnetic radiation can be modeled as waves or as fundamental particles.
- 6.G All matter can be modeled as waves or as particles.
- 7.C At the quantum scale, matter is described by a wave function, which leads to a probabilistic description of the microscopic world.

#### Essential Questions

*How do emission and absorption spectra occur?*

*How does the photoelectric effect exemplify the particle nature of light, and how does the de Broglie hypothesis suggest the wavelike nature of particles?*

*How are the concepts of momentum and energy in collisions applied to the scattering of photons by electrons?*

*How are mass–energy equivalence and charge and nucleon conservation laws applied to nuclear reactions?*

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ Fundamental particles have no internal structure.</li> <li>▪ Atoms have internal structures that determine their properties.</li> <li>▪ In certain processes, mass can be converted to energy and energy can be converted to mass according to <math>E = mc^2</math>, the equation derived from the theory of special relativity.</li> <li>▪ Objects classically thought of as particles can exhibit properties of</li> </ul>	<p><b>Research and Debate on Nuclear Energy:</b> Students work in pairs to investigate a socio-scientific issue: the pros and cons of the use of nuclear energy. The research should focus on the process of nuclear fission, the basic operation of a nuclear reactor, how a chain reaction works, and how magnetic and inertial confinements can</p>	<ul style="list-style-type: none"> <li>▪ The student is able to construct representations of the differences between a fundamental particle and a system composed of fundamental particles and to relate this to the properties and scales of the systems being investigated.</li> <li>▪ The student is able to construct representations of the energy-level structure of an electron in an atom and to relate this to the properties and scales of the systems being investigated.</li> <li>▪ The student is able to articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass-energy.</li> </ul>

**AP PHYSICS III – H**  
**UNIT 7: ATOMIC PHYSICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>waves.</p> <ul style="list-style-type: none"> <li>▪ Properties of space and time cannot always be treated as absolute</li> <li>▪ The strong force is exerted at nuclear scales and dominates the interactions of nucleons.</li> <li>▪ Mass can be converted into energy and energy can be converted into mass.</li> <li>▪ Energy transfer occurs when photons are absorbed or emitted, for example, by atoms or nuclei.</li> <li>▪ Beyond the classical approximation, mass is actually part of the internal energy of an object or system with <math>E = mc^2</math>.</li> <li>▪ Electric charge is conserved in nuclear and elementary particle reactions, even when elementary particles are produced or destroyed. Examples should include equations representing nuclear decay.</li> <li>▪ In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.</li> <li>▪ In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.</li> </ul>	<p>provide thermonuclear power.</p> <p><b>Radioactive Decay Simulations and Investigation:</b> To provide visual depictions of radioactive decay, use the “Alpha Decay” and “Beta Decay” simulations and discuss them with the class. Additionally, the simulations show a graph of half-life that helps students grasp the concept of the randomness of half-life.</p> <p><b>Photoelectric Effect Simulation:</b> The goal of this activity is for students to gather evidence to describe how the results of photoelectric effect investigations led to the photon model of light. Working individually, students use the “Photoelectric Effect” simulation to complete a guided-inquiry activity in which they predict the results of a variety of experiments involving the photoelectric effect.</p>	<ul style="list-style-type: none"> <li>▪ The student is able to explain why classical mechanics cannot describe all properties of objects by articulating the reasons that classical mechanics must be refined and an alternative explanation developed when classical particles display wave properties.</li> <li>▪ The student is able to articulate the reasons that classical mechanics must be replaced by special relativity to describe the experimental results and theoretical predictions that show that the properties of space and time are not absolute.</li> <li>▪ The student is able to identify the strong force as the force that is responsible for holding the nucleus together.</li> <li>▪ The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.</li> <li>▪ The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.</li> <li>▪ The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation <math>E = mc^2</math> to make a related calculation.</li> <li>▪ The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge.</li> <li>▪ The student is able to make predictions of the dynamical properties of a system undergoing a collision by application of the principle of linear momentum conservation and the principle of the conservation of energy in situations in which an elastic collision may also be assumed.</li> </ul>

**AP PHYSICS III – H**  
**UNIT 7: ATOMIC PHYSICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<ul style="list-style-type: none"> <li>▪ The velocity of the center of mass of the system cannot be changed by an interaction within the system. [Physics 1: includes no calculations of centers of mass; the equation is not provided until Physics 2. However, without doing calculations, Physics 1 students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or two spheres of equal mass.].</li> <li>▪ The possible nuclear reactions are constrained by the law of conservation of nucleon number.</li> <li>▪ Photons are individual energy packets of electromagnetic waves, with <math>E_{\text{photon}} = hf</math>, where <math>h</math> is Planck’s constant and <math>f</math> is the frequency of the associated light wave.</li> <li>▪ The nature of light requires that different models of light are most appropriate at different scales.</li> <li>▪ Under certain regimes of energy or distance, matter can be modeled as a classical particle.</li> <li>▪ Under certain regimes of energy or distance, matter can be modeled as a wave. The behavior in these regimes is described by quantum</li> </ul>		<ul style="list-style-type: none"> <li>▪ The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values</li> <li>▪ The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values.</li> <li>▪ The student is able to apply the conservation of linear momentum to an isolated system of objects involved in an inelastic collision.</li> <li>▪ The student is able to make predictions about the velocity of the center of mass for interactions within a defined one-dimensional system.</li> <li>▪ The student is able to make predictions about the velocity of the center of mass for interactions within a defined two-dimensional system.</li> <li>▪ The student is able to apply conservation of nucleon number and conservation of electric charge to make predictions about nuclear reactions and decays such as fission, fusion, alpha decay, beta decay, or gamma decay.</li> <li>▪ The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect.</li> <li>▪ The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter.</li> <li>▪ The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate.</li> <li>▪ The student is able to articulate the evidence supporting the</li> </ul>

**AP PHYSICS III – H**  
**UNIT 7: ATOMIC PHYSICS**

Grade Level Expectations	Instructional Strategies	Evidence of Learning
<p>mechanics.</p> <ul style="list-style-type: none"> <li>▪ The probabilistic description of matter is modeled by a wave function, which can be assigned to an object and used to describe its motion and interactions. The absolute value of the wave function is related to the probability of finding a particle in some spatial region. (Qualitative treatment only, using graphical analysis.)</li> <li>▪ The allowed states for an electron in an atom can be calculated from the wave model of an electron.</li> <li>▪ The spontaneous radioactive decay of an individual nucleus is described by probability.</li> <li>▪ Photon emission and absorption processes are described by probability.</li> </ul>		<p>claim that a wave model of matter is appropriate to explain the diffraction of matter interacting with a crystal, given conditions where a particle of matter has momentum corresponding to a de Broglie wavelength smaller than the separation between adjacent atoms in the crystal.</p> <ul style="list-style-type: none"> <li>▪ The student is able to predict the dependence of major features of a diffraction pattern (e.g., spacing between interference maxima) based upon the particle speed and de Broglie wavelength of electrons in an electron beam interacting with a crystal. (de Broglie wavelength need not be given, so students may need to obtain it.)</li> <li>▪ The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region.</li> <li>▪ The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region.</li> <li>▪ The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay.</li> <li>▪ The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay</li> </ul>

**AP PHYSICS III – H  
RESOURCES**

**PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>	<b>3<sup>rd</sup> Quarter</b>	<b>4<sup>th</sup> Quarter</b>
Unit 1: Electrostatics	X			
Unit 2: Electric Currents	X			
Unit 3: Fluids		X		
Unit 4: Magnetism and Induction		X		
Unit 5: Geometric Optics			X	
Unit 6: Thermodynamics			X	>
Unit 7: Atomic Physics				X



## **MARINE BIOLOGY – S COURSE DESCRIPTION**

### **MARINE BIOLOGY – S**

CREDIT: ½ credit

This is an introduction to the study of the oceans and coastal environments and the organisms that live there. There will be field trips to ocean-related facilities and use of the Project Oceanology resources at Avery Point. This course is designed for those students who do not intend on pursuing a degree in science. Emphasis will be placed on ecological concepts and human connections to the sea.

## MARINE BIOLOGY – S

### UNIT 1: INTRODUCTION TO MARINE SCIENCE

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Abilities of technological design
- Understandings about science and technology
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives
- Natural resources

#### Connecticut Content Standards:

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media
- Biological, chemical and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.

#### Essential Questions

*What impact does the ocean have on your life?*

*Why should we study the work of early marine scientists?*

*What social events influenced marine studies and technology at this time?*

*How did the technology of the twentieth century change marine science?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The history of Marine Biology is one of changing perspectives based on interpretation of historical and contemporary research and has shaped the modern science and its applications.</li> <li>▪ The polar nature and volume of water in the ocean account for its influence on the atmosphere, life and geology of the world.</li> <li>▪ The ocean influences weather, climate, gas content and circulation of the atmosphere</li> <li>▪ 1% of the oceans volume has been explored to date</li> <li>▪ Marine exploration has had 4 distinct periods of</li> </ul>	<ul style="list-style-type: none"> <li>▪ Marine Career activity</li> <li>▪ Ocean researcher trading cards</li> <li>▪ Design a research cruise</li> <li>▪ Reading activities – excerpts from Challenger exp., Darwin, Cousteau, Ballard</li> <li>▪ Why do we explore? - NOAA activities</li> </ul>	<ul style="list-style-type: none"> <li>▪ Diagram the air /sea interface and predict changes in climate and circulation based on data.</li> <li>▪ Create a timeline of ocean exploration.</li> <li>▪ Model an oceanic voyage by creating a plan of study, dive plan and designing tools needed for the expedition.</li> <li>▪ State that the oceans are an important source of food and other resources for humans and the study of them is critical to the health and well-being of humans and all organisms on Earth.</li> </ul>

**MARINE BIOLOGY – S**  
**UNIT 1: INTRODUCTION TO MARINE SCIENCE**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>growth</p> <ul style="list-style-type: none"> <li>▪ Understanding the history of oceanography is part of understanding how the oceans shaped the past and may shape the future</li> </ul>		<ul style="list-style-type: none"> <li>▪ Demonstrate the impact of the polar structure of water through various laboratory experiments.</li> </ul>
<ul style="list-style-type: none"> <li>▪ Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ROV design</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will design tools for collecting organisms from deep sea environments.</li> </ul>

## MARINE BIOLOGY – S

### UNIT 2: MARINE ECOSYSTEMS

#### National Science Education Standards:

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms
- Energy in the Earth system
- Geochemical cycles

#### National Science Education Standards (continued):

- Population growth
- Natural resources
- Natural and human induced hazards
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

#### Connecticut Content Standards:

- Stability in an ecosystem is a balance between competing effects.
- The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time.

#### Essential Questions

*How can over fertilizing your lawn lead to fish dying in Long Island Sound?*

*Where would a fisherman go to catch the most fish, and why?*

*Why would a coral reef have more diversity than Long Island Sound?*

*What structural changes would you make to your body so that you could survive as a planktonic animal?*

*Our water looks green, is that bad?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Different marine ecosystems have different environmental conditions and the organisms there reflect the adaptations to that environment.</li> <li>▪ Most marine organisms have evolved to have planktonic larvae due to the advantages.</li> <li>▪ Tropical waters are clear due to a lack of nutrients and climate plays a large role in this.</li> <li>▪ We have productive estuaries here due to the</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create a model ecosystem in groups</li> <li>▪ Simulate energy transfer in the open ocean</li> <li>▪ Create a board game based on an ecosystem</li> <li>▪ Create a CD of coral songs that describe various</li> </ul>	<ul style="list-style-type: none"> <li>▪ Model the fresh and salt water mixing in the laboratory.</li> <li>▪ Adopt conservation techniques that benefit marine ecosystems.</li> <li>▪ Describe the importance of coastal ecosystems.</li> <li>▪ Construct model marine ecosystems.</li> </ul>

**MARINE BIOLOGY – S**  
**UNIT 2: MARINE ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>physical mixing of the water.</p> <ul style="list-style-type: none"> <li>▪ Ocean and land ecosystems are interdependent.</li> <li>▪ Coastal ecosystems are very productive due to favorable abiotic conditions required for life while oceanic ecosystems are less productive due to a lack of those factors.</li> <li>▪ Protection of coastal ecosystems is important because commercially and ecologically important species spend at least part of their lives in these places.</li> <li>▪ The physical environment of oceanic ecosystems determines the organisms that will be found in each.</li> <li>▪ Marine organisms have developed life cycles, and different structures in each stage, that allow them to take advantage of different marine ecosystems at different stages of life</li> </ul>	<p>aspects of a coral reef ecosystem</p> <ul style="list-style-type: none"> <li>▪ Osmosis lab</li> <li>▪ Plankton lab</li> <li>▪ Bioluminescence lab</li> <li>▪ Estuary Lab</li> <li>▪ Mangrove study</li> <li>▪ Coral Propagation</li> <li>▪ Eutrophication lab</li> <li>▪ Coral reef modeling</li> <li>▪ Deep sea Hydrothermal vent model</li> <li>▪ Sea floor structure model</li> <li>▪ Reef relations activity</li> </ul>	<ul style="list-style-type: none"> <li>▪ Compare and contrast open ocean and coastal ecosystems.</li> <li>▪ Describe structural adaptations that allow organisms to thrive in different ecosystems.</li> </ul>
<p>Systems and System Models</p> <p>Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)</p>		<ul style="list-style-type: none"> <li>▪ Students will model an ecosystem in an aquarium and be able to match environmental conditions, biological inhabitants and microbial/nutrient cycles to the natural ecosystem/community</li> </ul>

## **MARINE BIOLOGY – S RESOURCES**

- Marine Science: Pearson (ISBN10: 0133192172, ISBN 13: 9780133192179)
- Laboratory and Field Investigations in Marine Life, Ninth Edition, James L. Sumich ISBN-13: 9780763757304
- Blue planet video series – ocean ecosystems
- Tank set up for each ecosystem – specific tank designs will require specialized equipment – see attached equipment requests
- Salt, filters, feed, living organisms
- Field equipment

### **PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>
Unit 1: Introduction to Marine Science	X	
Unit 2: Marine Ecosystems	X	>

## MARINE BIOLOGY – S COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## MARINE BIOLOGY – S COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)



## **MARINE BIOLOGY I – A – MARINE ECOSYSTEMS COURSE DESCRIPTION**

### **MARINE BIOLOGY I – A – MARINE ECOSYSTEMS**

CREDIT: ½ credit

This is a survey course of the living ecosystems in the ocean. Subjects will include a survey of the major marine ecosystems, ecological relationships and adaptations. The course will take an ecosystems approach to looking at life in the sea. We will start with a look at marine ecosystems around the world including coral reefs, deep sea and kelp forests and then focus on our local estuarine ecosystem.

## MARINE BIOLOGY I – A – MARINE ECOSYSTEMS

### UNIT 1: INTRODUCTION TO MARINE ECOSYSTEMS

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Abilities of technological design
- Understandings about science and technology
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives
- Natural resources

#### Connecticut Content Standards:

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media
- Biological, chemical and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.

#### Essential Questions

*What impact does the ocean have on your life?*

*Why should we study the work of early marine scientists?*

*What social events influenced marine studies and technology at this time?*

*How did the technology of the twentieth century change marine science?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The history of Marine Biology is one of changing perspectives based on interpretation of historical and contemporary research and has shaped the modern science and its applications.</li> <li>▪ The polar nature and volume of water in the ocean account for its influence on the atmosphere, life and geology of the world.</li> <li>▪ The ocean influences weather, climate, gas content and circulation of the atmosphere</li> <li>▪ Marine exploration has had 4 distinct periods of growth</li> <li>▪ Understanding the history of oceanography is part of understanding how the oceans shaped the past and may shape the future</li> </ul>	<ul style="list-style-type: none"> <li>▪ Marine Career activity</li> <li>▪ Ocean researcher trading cards</li> <li>▪ Design a research cruise</li> <li>▪ Reading activities – excerpts from Challenger exp., Darwin, Coustaeu, Ballard</li> <li>▪ Why do we explore? -</li> </ul>	<ul style="list-style-type: none"> <li>▪ Diagram the air /sea interface and predict changes in climate and circulation based on data.</li> <li>▪ Create a timeline of ocean exploration.</li> <li>▪ Model an oceanic voyage by creating a plan of study, dive plan and designing tools needed for the expedition.</li> <li>▪ State that the oceans are an important source of food and other resources for humans and</li> </ul>

**MARINE BIOLOGY I – A – MARINE ECOSYSTEMS**  
**UNIT 1: INTRODUCTION TO MARINE ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The ocean is the largest unexplored place on Earth—less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.</li> <li>▪ Most of Earth’s water (97%) is in the ocean. Seawater has unique properties. It is salty, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. Balance of pH is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.</li> <li>▪ The ocean is the defining physical feature on our planet Earth—covering approximately 70% of the planet’s surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern, and Arctic.</li> <li>▪ Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators, and illustrators. And these interactions foster new ideas and new perspectives for inquiries.</li> <li>▪ Use of mathematical models is an essential part of understanding the ocean system. Models help us understand the complexity of the ocean and its interactions with Earth’s interior, atmosphere, climate, and land masses.</li> <li>▪ New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.</li> <li>▪ Over the last 50 years, use of ocean resources has increased</li> </ul>	<p style="text-align: center;">NOAA activities</p>	<p>the study of them is critical to the health and well-being of humans and all organisms on Earth.</p> <ul style="list-style-type: none"> <li>▪ Demonstrate the impact of the polar structure of water through various laboratory experiments.</li> </ul>

**MARINE BIOLOGY I – A – MARINE ECOSYSTEMS**  
**UNIT 1: INTRODUCTION TO MARINE ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.</p> <ul style="list-style-type: none"> <li>▪ Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.</li> <li>▪ The ocean is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to coastal estuaries and to the ocean.</li> <li>▪ Although the ocean is large, it is finite, and resources are limited.</li> </ul>		
<ul style="list-style-type: none"> <li>▪ Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ROV Design</li> </ul>	<ul style="list-style-type: none"> <li>▪ Students will design tools for collecting organisms from deep sea environments.</li> </ul>

## MARINE BIOLOGY I – A – MARINE ECOSYSTEMS

### UNIT 2: MARINE ECOSYSTEMS

#### National Science Education Standards:

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms
- Energy in the Earth system
- Geochemical cycles

#### National Science Education Standards (continued):

- Population growth
- Natural resources
- Natural and human induced hazards
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

#### Connecticut Content Standards:

- Stability in an ecosystem is a balance between competing effects.
- The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time.

#### Essential Questions

*How can over fertilizing your lawn lead to fish dying in Long Island Sound?*

*Where would a fisherman go to catch the most fish, and why?*

*Why would a coral reef have more diversity than Long Island Sound?*

*What structural changes would you make to your body so that you could survive as a planktonic animal?*

*Our water looks green, is that bad?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Different marine ecosystems have different environmental conditions and the organisms there reflect the adaptations to that environment.</li> <li>▪ Most marine organisms have evolved to have planktonic larvae due to the advantages.</li> <li>▪ Tropical waters are clear due to a lack of nutrients and climate plays a large role in this.</li> <li>▪ We have productive estuaries here due to the physical mixing of</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create a model ecosystem in groups</li> <li>▪ Simulate energy transfer in the open ocean</li> <li>▪ Create a board game based on an ecosystem</li> <li>▪ Create a CD of coral songs that describe</li> </ul>	<ul style="list-style-type: none"> <li>▪ Model the fresh and salt water mixing in the laboratory.</li> <li>▪ Adopt conservation techniques that benefit marine ecosystems.</li> <li>▪ Describe the importance of coastal ecosystems.</li> <li>▪ Construct model marine</li> </ul>

**MARINE BIOLOGY I – A – MARINE ECOSYSTEMS**  
**UNIT 2: MARINE ECOSYSTEMS**

<p style="text-align: center;"><b>Grade Level Expectations</b>  <b>Disciplinary Core Ideas (DCIs)</b>  <i>Students will know:</i></p>	<p style="text-align: center;"><b>Instructional Strategies</b></p>	<p style="text-align: center;"><b>Evidence of Learning</b>  <b>S and E Practices</b>  <i>Students will be able to:</i></p>
<p>the water.</p> <ul style="list-style-type: none"> <li>▪ Ocean and land ecosystems are interdependent.</li> <li>▪ Coastal ecosystems are very productive due to favorable abiotic conditions required for life while oceanic ecosystems are less productive due to a lack of those factors.</li> <li>▪ Protection of coastal ecosystems is important because commercially and ecologically important species spend at least part of their lives in these places.</li> <li>▪ The physical environment of oceanic ecosystems determines the organisms that will be found in each.</li> <li>▪ Marine organisms have developed life cycles, and different structures in each stage, that allow them to take advantage of different marine ecosystems at different stages of life.</li> <li>▪ Ocean ecosystems are defined by environmental factors and the community of organisms living there. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, nutrients, pressure, substrate, and circulation. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.</li> <li>▪ The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean.</li> <li>▪ There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps, rely only on chemical energy and chemosynthetic organisms to support life.</li> </ul>	<p>various aspects of a coral reef ecosystem</p> <ul style="list-style-type: none"> <li>▪ Osmosis lab</li> <li>▪ Plankton lab</li> <li>▪ Bioluminescence lab</li> <li>▪ Estuary Lab</li> <li>▪ Mangrove study</li> <li>▪ Coral Propagation</li> <li>▪ Eutrophication lab</li> <li>▪ Coral reef modeling</li> <li>▪ Deep sea Hydrothermal vent model</li> <li>▪ Sea floor structure model</li> <li>▪ Reef relations activity</li> </ul>	<p>ecosystems.</p> <ul style="list-style-type: none"> <li>▪ Compare and contrast open ocean and coastal ecosystems.</li> <li>▪ Describe structural adaptations that allow organisms to thrive in different ecosystems.</li> </ul>

**MARINE BIOLOGY I – A – MARINE ECOSYSTEMS**  
**UNIT 2: MARINE ECOSYSTEMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast; density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms’ distribution and diversity.</li> <li>▪ The ocean dominates Earth’s carbon cycle. Half of the primary productivity on Earth takes place in the sunlit layers of the ocean. The ocean absorbs roughly half of all carbon dioxide and methane that are added to the atmosphere.</li> </ul>		
<p>Systems and System Models Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)</p>		<ul style="list-style-type: none"> <li>▪ Students will model an ecosystem in an aquarium and be able to match environmental conditions, biological inhabitants and microbial/nutrient cycles to the natural ecosystem/community.</li> </ul>

## **MARINE BIOLOGY I – A – MARINE ECOSYSTEMS RESOURCES**

- Marine Biology 7e Castro and Huber (ISBN 978-0-07-302819)
- Laboratory and Field Investigations in Marine Life, Ninth Edition, James L. Sumich ISBN-13: 9780763757304
- Blue planet video series – ocean ecosystems
- Tank set up for each ecosystem – specific tank designs will require specialized equipment – see attached equipment requests
- Salt, filters, feed, living organisms
- Field equipment

### **PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>
Unit 1: Introduction to Marine Science	X	
Unit 2: Marine Ecosystems	X	>



## MARINE BIOLOGY I – A – MARINE ECOSYSTEMS COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## MARINE BIOLOGY I – A – MARINE ECOSYSTEMS COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## **MARINE BIOLOGY II – A – MARINE ORGANISMS COURSE DESCRIPTION**

### **MARINE BIOLOGY II – 1 – MARINE ORGANISMS**

CREDIT: ½ credit

This is a survey course of the life in the ocean. Subjects will include anatomy and physiology of marine organisms, evolutionary relationships and adaptations. The course will take a phylogenetic approach to looking at life in the sea. We will start with simple groups and move to more complex.

## MARINE BIOLOGY II – A – MARINE ORGANISMS

### UNIT 1: INTRODUCTION TO MARINE ORGANISMS

#### National Science Education Standards:

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems

#### National Science Education Standards (continued):

- Behavior of organisms
- Abilities of technological design
- Understandings about science and technology
- Personal and community health
- Natural resources
- Environmental quality
- Natural and human induced hazards

Science and technology in local, national, and global challenges

#### Connecticut Content Standards:

- Mutation and sexual reproduction lead to genetic variation in a population.

#### Essential Questions

*Which is an easier place to live, water or land?*

*What makes Jellyfish float?*

*Why is most life on Earth found in the ocean?*

*Are Dolphins and Sharks related because they have similar body shapes?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The requirements for life in the ocean are different than those for life on land.</li> <li>▪ The ocean contains representatives from every phyla of organisms found on Earth and contains most of the life on Earth.</li> <li>▪ The organisms on Earth are categorized into groups, which reflect relationships described by evolutionary theory and are based on historical and current observations.</li> <li>▪ Ocean organisms have evolved to meet the environmental demands of the ecosystem in which they live.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Conduct experiments and dissections of various marine organisms</li> <li>▪ Simulate energy transfer in the open ocean</li> <li>▪ Create a 3d model of a planktonic organism and describe how the form matches the function.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Compare and contrast seaweeds with flowering plants.</li> <li>▪ Relate the anatomy of marine organisms to the environment in which they live.</li> <li>▪ Identify marine organisms using dichotomous keys.</li> <li>▪ List 5 organisms from each of the marine phyla studied.</li> </ul>

**MARINE BIOLOGY II – A – MARINE ORGANISMS**  
**UNIT 1: INTRODUCTION TO MARINE ORGANISMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Marine organisms represent almost every phyla of animals on the planet.</li> <li>▪ The majority of life on the planet is in the ocean.</li> <li>▪ The majority of life in the sea is found at the surface.</li> <li>▪ Organisms are organized into groups based on structure, DNA and genetic similarity.</li> <li>▪ Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth’s atmosphere was necessary for life to develop and be sustained on land.</li> <li>▪ The ocean is the cradle of life; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.</li> <li>▪ The ocean provided and continues to provide water, oxygen, and nutrients, and moderates the climate needed for life to exist on Earth</li> <li>▪ Ocean life ranges from the smallest living things, microbes , to the largest animal on Earth, Blue Whales</li> <li>▪ Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the carbon and oxygen on Earth.</li> <li>▪ Most of the major groups that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land</li> <li>▪ Ocean biology provides many unique examples of life cycles,</li> </ul>	<ul style="list-style-type: none"> <li>▪ Concept maps</li> <li>▪ Tests, quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<ul style="list-style-type: none"> <li>▪ Describe 5 characteristics that identify each of the groups of organisms studied.</li> <li>▪ Compare the anatomy of the three classes of fish and describe the advantages and disadvantages of the different structural adaptations.</li> </ul>

**MARINE BIOLOGY II – A – MARINE ORGANISMS**  
**UNIT 1: INTRODUCTION TO MARINE ORGANISMS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land</p> <ul style="list-style-type: none"> <li>▪ The ocean is the largest reservoir of rapidly cycling carbon on Earth. Many organisms use carbon dissolved in the ocean to form shells, other skeletal parts, and coral reefs.</li> </ul>		

## MARINE BIOLOGY II – A – MARINE ORGANISMS

### UNIT 2: EXPLORATION OF HUMANS AND THE SEA

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Interdependence of organisms
- Behavior of organisms
- Abilities of technological design
- Understandings about science and technology
- Personal and community health

#### National Science Education Standards (continued):

- Population growth
- Natural resources
- Environmental quality
- Natural and human induced hazards
- Science and technology in local, national, and global challenges

#### Connecticut Content Standards:

- Mutation and sexual reproduction lead to genetic variation in a population

#### Essential Questions

*Which is an easier place to live, water or land?*  
*Why is most life on Earth found in the ocean?*  
*How are marine organisms structurally suited for their environments?*  
*Why is most life in the ocean found at the surface, near the shore?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The sea is an important source of minerals, energy reserves, metals and food.</li> <li>▪ Over fishing has brought some fisheries to the point of collapse.</li> <li>▪ Large numbers of non-commercial animals are killed as a by-catch of fishing.</li> <li>▪ Pollution from land, including solid waste, runoff and sewage, have negative impacts on the ocean.</li> <li>▪ Development of coastal areas leads to loss of habitat and decreased marine life.</li> <li>▪ Conservation of the oceans and coastal habitats is crucial for life as</li> </ul>	<ul style="list-style-type: none"> <li>▪ Es tu aware y – awareness review game</li> <li>▪ Beach clean up</li> <li>▪ Role play ocean pollution solutions</li> <li>▪ Aquaculture activity</li> <li>▪ Concept maps</li> <li>▪ Tests, Quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<ul style="list-style-type: none"> <li>▪ Describe at least 10 commercially important marine species.</li> <li>▪ Design and conduct lab experiments to model and determine human impacts on the marine environment</li> <li>▪ List marine organisms currently used in biomedical research and describe the effects each has had on</li> </ul>

**MARINE BIOLOGY II – A – MARINE ORGANISMS**  
**UNIT 2: EXPLORATION OF HUMANS AND THE SEA**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>we know it.</p> <ul style="list-style-type: none"> <li>▪ They have an impact on the ocean and the ocean has an impact on them</li> <li>▪ Marine aquaculture holds a lot of promise for solving world seafood issues</li> <li>▪ Nitrogen pollution is our number 1 coastal pollution problem</li> <li>▪ Marine fisheries are in serious decline</li> <li>▪ The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth’s oxygen. The ocean moderates the Earth’s climate, influences our weather, and affects human health.</li> <li>▪ The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.</li> <li>▪ The ocean is a source of inspiration, recreation, rejuvenation, and discovery. It is also an important element in the heritage of many cultures. Humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, nonpoint source, and noise pollution), changes to ocean chemistry (ocean acidification), and physical modifications (changes to beaches, shores, and rivers). In addition, humans have removed most of the large vertebrates from the ocean.</li> <li>▪ Changes in ocean temperature and pH due to human activities can affect the survival of some organisms and impact biological diversity (coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification).</li> </ul>		<p>human health</p> <ul style="list-style-type: none"> <li>▪ Adopt a conservationist point of view and defend, in writing and orally in role-play settings, the need for developmental planning and conservation on land in order to protect marine habitats.</li> <li>▪ Hold an informed debate on marine resources management.</li> <li>▪ Compare benefits and drawbacks to mariculture practices</li> </ul>



**MARINE BIOLOGY II – A – MARINE ORGANISMS  
UNIT 2: EXPLORATION OF HUMANS AND THE SEA**

<b>Grade Level Expectations Disciplinary Core Ideas (DCIs)</b> <i>Students will know:</i>	<b>Instructional Strategies</b>	<b>Evidence of Learning S and E Practices</b> <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Much of the world’s population lives in coastal areas. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).</li> <li>▪ Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.</li> </ul>		

**MARINE BIOLOGY II – A – MARINE ORGANISMS  
RESOURCES**

- Marine Biology 7e Castro and Huber (ISBN 978-0-07-302819)
- Laboratory and Field Investigations in Marine Life, Ninth Edition, James L. Sumich ISBN-13: 9780763757304
- Videos
- Magazines
- Equipment
- Supplies

**PACING GUIDE**

<b>Unit</b>	<b>1<sup>st</sup> Quarter</b>	<b>2<sup>nd</sup> Quarter</b>
Unit 1: Introduction to Marine Organisms	X	
Unit 2: Exploration of Humans and the Sea	X	>

## MARINE BIOLOGY II – A – MARINE ORGANISMS COMMON CORE CONNECTIONS

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

## MARINE BIOLOGY II – A – MARINE ORGANISMS COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

## UCONN ECE MARINE SCIENCE – H COURSE DESCRIPTION

### UCONN ECE MARINE SCIENCE – H

CREDIT: 1 credit

This is a college level class carrying honors credit and expectations. Students taking this class will have the opportunity to get UCONN credit for the class. This class will focus on the biological, chemical, and geophysical aspects of the ocean. Students taking the class will have access to the UCONN Avery Point campus library and lab facilities and online resources. Field programs will include trips the Avery Point Marine Science Building for lab work as well as Project O for boat trips.

## UCONN ECE MARINE SCIENCE – H

### UNIT 1: INTRODUCTION TO OCEANOGRAPHY

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Conservation of energy and increase in disorder
- Interactions of energy and matter
- Origin and evolution of the Earth system
- Natural resources
- Science and technology in local, national, and global challenges
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

#### Connecticut Content Standards:

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.
- Biological, chemical and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.
- Each element on Earth moves among reservoirs which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles.
- Plate tectonics operating over geologic time has changed the patterns of land, sea and mountains on Earth's surface.

#### Essential Questions

- What impact does the ocean have on your life?*
- What structures enable your favorite marine animal to live where it does in the ocean?*
- How could molecules from your breakfast end up in the shell of a clam?*
- Why should we study the work of early oceanographers?*
- How did the technology of the twentieth century change marine science?*
- What social events influenced marine studies and technology at this time?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The deep oceanic basin floor covers more of Earth’s surface (30%) than the exposed continental land surface (29%) and is an area that can be just as rugged as the continents. There are a variety of features that rise up above the deep-ocean floor and there are regions that extend to significantly greater depths.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create synthetic sea water from scratch</li> <li>▪ Determine salinity from conductivity, refraction, density, titration and evaporation</li> <li>▪ Online webquest on</li> </ul>	<ul style="list-style-type: none"> <li>▪ Diagram the air /sea interface and predict changes in climate and circulation based on data.</li> <li>▪ Create a timeline of ocean exploration.</li> <li>▪ Model an oceanic voyage by</li> </ul>

**UConn ECE Marine Science – H**  
**UNIT 1: INTRODUCTION TO OCEANOGRAPHY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The ocean is the defining physical feature on our planet Earth—covering approximately 70% of the planet’s surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic,</li> <li>▪ South Atlantic, Indian, Southern, and Arctic.</li> <li>▪ Our ability to accurately map the features of the sea floor has been acquired only recently and continues to improve with advancing technology.</li> <li>▪ Earth's tectonic plates have moved great distances and at varying rates throughout much of the geologic past. Many geologic features, and some new techniques such as assessing the ancient or paleo-magnetic patterns locked in rocks as they cool, can help us to decipher the history and behavior of the plates.</li> <li>▪ There are two types of continental margins: trailing margins are closest to the divergent plate boundary, and leading margins are closest to the convergent plate boundary.</li> <li>▪ Understanding the history of oceanography is part of understanding how the oceans shaped the past and may shape the future.</li> <li>▪ The concepts of continental drift and sea floor spreading have been combined to form a single unified theory of the dynamic behavior of Earth called “plate tectonics”.</li> <li>▪ The sea floor is not a static environment but is in motion as new sea floor is created at oceanic ridges and an equal volume is destroyed at deep trenches.</li> <li>▪ Marine exploration has had 4 distinct periods of growth.</li> <li>▪ Less than 5% of the oceans volume has been explored to date.</li> <li>▪ The ocean is directly or indirectly responsible for the majority</li> </ul>	<p>history of marine science</p> <ul style="list-style-type: none"> <li>▪ Map the sea floor activity</li> <li>▪ Sea floor spreading activity</li> <li>▪ Concept maps</li> <li>▪ Tests, quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<p>creating a plan of study, dive plan and designing tools needed for the expedition.</p> <ul style="list-style-type: none"> <li>▪ Create a 3d model of the sea floor.</li> <li>▪ Identify sea floor structures</li> <li>▪ estimate the age of the sea floor from magnetic stripe information</li> <li>▪ Identify the ocean basins and describe the formation and ecological importance of the geologic structures similar to each.</li> <li>▪ Demonstrate the impact of the polar structure of water through various laboratory experiments.</li> </ul>

**UConn ECE Marine Science – H**  
**UNIT 1: INTRODUCTION TO OCEANOGRAPHY**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>of the food on the planet.</p> <ul style="list-style-type: none"> <li>▪ The ocean influences weather, climate, gas content and circulation of the atmosphere.</li> <li>▪ Scientists who study the oceans have many different scientific backgrounds. Essentially any scientific discipline can be applied to some sub-field of oceanography.</li> <li>▪ The history of Oceanography is one of changing perspectives based on interpretation of historical and contemporary research and has shaped the modern science and its applications.</li> <li>▪ Scientists study the natural world through a careful process of observation and experimentation.</li> <li>▪ The polar nature and volume of water in the ocean account for its influence on the atmosphere, life and geology of the world.</li> <li>▪ Earth is unique among the planets because its surface temperature and composition allow water to exist as a gas, liquid, and solid.</li> </ul>		
<ul style="list-style-type: none"> <li>▪ HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Given specific investigative parameters, students will design a manned submersible with instrumentation designed to fit the mission parameters.</li> </ul>	<ul style="list-style-type: none"> <li>▪</li> </ul>

## UCONN ECE MARINE SCIENCE – H

### UNIT 2: INTRODUCTION TO OCEAN MOTION

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Conservation of energy and increase in disorder
- Interactions of energy and matter
- Energy in the Earth system
- Geochemical cycles
- Abilities of technological design
- Understandings about science and technology
- Natural resources

#### National Science Education Standards (continued):

- Science and technology in local, national, and global challenges
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

#### Connecticut Content Standards:

- Waves have characteristic properties that do not depend on the type of wave.
- Energy cannot be created or destroyed although, in many processes, energy is transferred to the environment as heat.
- Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

#### Essential Questions

*Why doesn't England get as cold as Alaska even though they are at the same latitude?*

*What creates waves?*

*Why are there some tides that are more extreme?*

*Why does Waterford get fewer snow days than Norwich?*

*Why doesn't the ocean freeze?*

*What is a tsunami?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Earth receives solar radiation unequally over its surface; with the intensity per unit area of surface greatest at the equator, intermediate in the middle latitudes, and the lowest intensity is at the polar regions.</li> <li>▪ Earth must lose an amount of heat back to space that is equal to the amount it gains from the sun or else Earth's average temperature, about 16°C, would increase or decrease with time.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Wave tank Experiments</li> <li>▪ Wave, current and tide calculation activities</li> <li>▪ Ocean Circulation activity</li> <li>▪ Davey Jones locker</li> </ul>	<ul style="list-style-type: none"> <li>▪ Graph tidal cycles from different areas of the world.</li> <li>▪ Calculate wave speed, height and frequency.</li> <li>▪ Create and measure wave</li> </ul>



**UCONN ECE MARINE SCIENCE – H**  
**UNIT 2: INTRODUCTION TO OCEAN MOTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The intensity of solar radiation available at Earth’s surface varies with latitude and the time of year.</li> <li>▪ Two fluid bodies blanket the solid Earth, the atmosphere surrounding the globe and the oceans covering most of its surface.</li> <li>▪ Density differences in the atmosphere result in pressure differences at the surface.</li> <li>▪ Water mass density is controlled by water temperature and salinity. Many combinations of temperature and salinity can create the same density.</li> <li>▪ Dense water sinking in the oceans reaches an equilibrium depth and is then driven horizontally by the continued sinking of dense water behind it. Water at the surface moves into the zone of sinking, while at some other point in the ocean, water must rise to replace it.</li> <li>▪ Waves are created as the result of a generating force. An additional force, called the restoring force, acts to return the surface of the water to its original flat level.</li> <li>▪ As waves move into shallow water or encounter obstacles in their path, they may be refracted, reflected, or diffracted.</li> <li>▪ Submarine earthquakes that cause vertical displacements of the sea floor can generate massive waves on the sea surface called tsunamis.</li> <li>▪ The tides rise and fall in response to forces generated by the Sun and the Moon and the rotation of the Earth-Moon system about their common center of mass.</li> <li>▪ The average ocean salinity is about 35 ppt.</li> <li>▪ At polar latitudes the salinity of the water varies annually. In the winter the formation of sea ice concentrates the salt and increases the salinity. In the summer the melting ice reduces the salinity</li> <li>▪ Less dense water masses remain at the ocean’s surface, while more dense waters tend to sink to an equilibrium level. These simple physical</li> </ul>	<p style="text-align: center;">activity</p> <ul style="list-style-type: none"> <li>▪ Remote sensing activity</li> <li>▪ Concept maps</li> <li>▪ Tests, quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<p style="text-align: center;">patterns.</p>

**UConn ECE MARINE SCIENCE – H**  
**UNIT 2: INTRODUCTION TO OCEAN MOTION**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>reactions, coupled with wind, tidal, and wave generated forces, means that the density of the ocean waters changes with depth, latitude, and proximity to coastal regions in a fairly predictable (and observable) manner.</p> <ul style="list-style-type: none"> <li>▪ There are 3 major patterns of tides – diurnal, semi diurnal and mixed.</li> <li>▪ Tides are influenced by the moon, Sun, Earth’s rotation and local geography.</li> <li>▪ There are many different types of waves and the type and characteristics are influenced by fetch, geology and physical processes.</li> <li>▪ Waves transfer energy from one place to another.</li> <li>▪ When currents twist and close on themselves they can trap water from one side of the current on the opposite side.</li> <li>▪ The major gyres in the Northern Hemisphere rotate clockwise, while in the Southern Hemisphere they rotate counterclockwise.</li> <li>▪ Large circular surface currents called gyres dominate the wind-driven surface circulation in each hemisphere.</li> <li>▪ Surface circulation is a response to the long-term average atmospheric circulation.</li> <li>▪ Prevailing winds in the atmosphere drive surface currents in the oceans in predictable patterns.</li> <li>▪ In the open ocean seasonal temperature changes are more important than changes in salinity in controlling density.</li> <li>▪ Areas where water masses move downward are called down welling zones, and conversely, areas where water rises are called upwelling zones.</li> </ul>		

## UCONN ECE MARINE SCIENCE – H

### UNIT 3: INTRODUCTION TO COASTAL OCEANS

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Conservation of energy and increase in disorder
- Interactions of energy and matter
- Energy in the Earth system
- Geochemical cycles
- Abilities of technological design
- Understandings about science and technology
- Population growth
- Natural resources

#### National Science Education Standards (continued):

- Natural and human induced hazards
- Science as a human endeavor
- Nature of scientific knowledge
- Science and technology in local, national, and global challenges

#### Connecticut Content Standards:

- The use of resources by human populations may affect the quality of the environment.
- Elements on Earth move among reservoirs in the solid earth, oceans, atmosphere and organisms as part of biogeochemical cycles.

#### Essential Questions:

*Why does the beach go away in winter?*  
*Why can't I just build a sea wall to protect my beach?*  
*Where does beach sand go?*  
*Why are beaches around the world so different?*  
*What is a rip current?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ The coastal zone includes open coasts and bays and estuaries, i.e., a coastal zone are both land and water.</li> <li>▪ The beach is an accumulation of sediment (commonly coarser grain sizes such as sands and gravels) that occupies a portion of the shoreline, commonly up to the high tide levels.</li> <li>▪ Beach areas are not static, and sediments shift and move along, in, and out of beach or shoreline areas constantly.</li> <li>▪ Coasts are classified as being either erosional or depositional depending on</li> </ul>	<ul style="list-style-type: none"> <li>▪ Wave tank Experiments with coastal structures</li> <li>▪ Beach trip for profile</li> <li>▪ Sediment and Estuaries labs</li> <li>▪ Remote sensing activity – for beach erosion</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create model coastlines and determine impacts of man-made structures on circulation patterns.</li> <li>▪ Monitor beach erosion.</li> <li>▪ Graph elevation</li> </ul>

**UCONN ECE MARINE SCIENCE – H**  
**UNIT 3: INTRODUCTION TO COASTAL OCEANS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>whether they predominantly lose or gain sediment.</p> <ul style="list-style-type: none"> <li>▪ Primary coasts are created and maintained by terrestrial or land-based processes. Primary coasts may be formed by: <ul style="list-style-type: none"> <li>○ erosion of the land and potential subsidence or sea level rises,</li> <li>○ sediments deposited at the shore by rivers, glaciers, or the wind,</li> <li>○ volcanic activity, and vertical movements of the shoreline by tectonic processes.</li> </ul> </li> <li>▪ Secondary coasts are created and maintained by predominantly marine processes. These coasts may be formed by: <ul style="list-style-type: none"> <li>○ erosion by waves and currents,</li> <li>○ dissolution by seawater,</li> <li>○ deposition of sediments by waves, tides, and currents,</li> <li>○ erosion, deposition, and binding of sediments and skeletal materials by marine plants and animals</li> </ul> </li> <li>▪ Glacial periods tie up seawater in land ice, lowering global sea level.</li> <li>▪ The shore may be subdivided into three major regions called the backshore, foreshore, and offshore.</li> <li>▪ Gentle summer waves tend to deposit sand onto the beach, while stronger winter storm waves (that may come from quite a different direction) will remove sandy materials from a beach, depositing them offshore as sandbars.</li> <li>▪ Waves approaching the coast within the surf zone produce a current, whereby particles of suspended and bottom sediments are transported onshore in what are termed onshore current and onshore transport, respectively.</li> <li>▪ As wave crests do not approach or break in the surf zone exactly parallel to the coast, the small angular difference sets up another current, called the longshore current.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Concept maps</li> <li>▪ Tests, quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<p>changes on a beach.</p> <ul style="list-style-type: none"> <li>▪ Determine circulation patterns in model estuaries.</li> <li>▪ Create and measure specific circulation patterns.</li> <li>▪ Determine estuarine flushing rates.</li> <li>▪ Track sediment movement on a local beach.</li> </ul>

## UCONN ECE MARINE SCIENCE – H

### UNIT 4: INTRODUCTION TO THE LIVING SEAS

#### National Science Education Standards:

- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms
- Energy in the Earth system
- Geochemical cycles
- Understandings about science and technology
- Personal and community health

#### National Science Education Standards (continued):

- Natural resources
- Environmental quality
- Natural and human induced hazards
- Science and technology in local, national, and global challenges
- Science as a human endeavor
- Nature of scientific knowledge

#### Connecticut Content Standards:

- Stability in an ecosystem is a balance between competing effects.
- The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism’s cells.

#### Essential Questions

*How many species live in the sea?*

*What is life like at the bottom of the sea?*

*How is life in the sea different that on land?*

*How do eels migrate such long distances and through such differing salinities and depths?*

*How do organisms float in the sea?*

*Can adding iron to the sea decrease global warming?*

*Where does the oxygen we breathe come from?*

*What impact does increased CO2 have on marine life?*

*How do organisms in the deep sea communicate?*

*Why should we care about coral reefs?*

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ Coral reefs are delicate ecosystems susceptible to bleaching, predation, and disease.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Live organism and observation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Determine primary production in coastal waters.</li> </ul>

**UCONN ECE MARINE SCIENCE – H**  
**UNIT 4: INTRODUCTION TO THE LIVING SEAS**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<ul style="list-style-type: none"> <li>▪ There are unique communities of organisms that are tied to a process of chemosynthesis to generate biomass and energy for life.</li> <li>▪ Benthic animals, unlike algae, are found at all depths and on all kinds of substrate. There are 50 times more benthic (over 150,000) than pelagic (about 3000) marine animal species.</li> <li>▪ Intertidal environments are subject to rapid and drastic environmental changes and the distribution of organisms that live there is governed by their ability to deal with the stresses brought on by periodic exposure, the high energy of wave and tidal turbulence, and other extreme changes in chemical and physical parameters.</li> <li>▪ Marine organisms sometimes settle and grow on structures. This is called fouling.</li> <li>▪ Coral reefs are one of the most unique, diverse, relatively self-contained benthic communities on Earth.</li> <li>▪ The large, benthic, multicellular seaweeds are members of a group called algae.</li> <li>▪ Pigment colors are used to classify algae, or seaweed.</li> <li>▪ There are 50 times more benthic (over 150,000) than pelagic (about 3000) marine animal species.</li> <li>▪ There are two basic subdivisions of benthic organisms:               <ul style="list-style-type: none"> <li>○ the epifauna, animals that live on or attached to the bottom (80% of benthic organisms), and</li> <li>○ the infauna, animals that live buried in the soft sediments of the sea floor such as mud and sand.</li> </ul> </li> <li>▪ Animals, either sessile or motile, produce motile planktonic larvae.</li> <li>▪ Animals in rocky intertidal areas arrange themselves in a vertical or intertidal zonation.</li> <li>▪ Animals in rocky intertidal areas arrange themselves in a vertical or</li> </ul>	<ul style="list-style-type: none"> <li>experiments</li> <li>▪ Field trips to rocky shore, marsh, mudflat and beach</li> <li>▪ Marine mammal necropsy</li> <li>▪ Marine Invertebrate dissections</li> <li>▪ Fish Dissections</li> <li>▪ Concept maps</li> <li>▪ Tests, quizzes</li> <li>▪ Discussion</li> <li>▪ Labs</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use a dichotomous key to identify organisms.</li> <li>▪ Determine marine algae classification from chromatography.</li> <li>▪ Determine circulation patterns in model estuaries.</li> <li>▪ Compare planktonic concentrations from season to season and compare geographically.</li> <li>▪ Document marine fouling over time.</li> <li>▪ Identify vertical zones in the intertidal area.</li> <li>▪ Compare diversity of beach versus marsh communities.</li> <li>▪ Identify the zone an organism is from by studying its external and internal features.</li> <li>▪ Compare marine mammal physiology with that of other mammals and humans.</li> <li>▪ Identify and explain functional adaptations in marine organisms.</li> <li>▪ Measure the impact of excess nutrients on coastal</li> </ul>

**UConn ECE Marine Science – H**  
**Unit 4: Introduction to the Living Seas**

Grade Level Expectations Disciplinary Core Ideas (DCIs) <i>Students will know:</i>	Instructional Strategies	Evidence of Learning S and E Practices <i>Students will be able to:</i>
<p>intertidal zonation.</p> <ul style="list-style-type: none"> <li>▪ High-energy beach areas are unstable, and lack the amount of algal and animal life we see in the rocky intertidal areas. Moreover, zonation is much less defined.</li> <li>▪ Low-energy, soft-sediment environments are much more favorable for more diverse and more numerically abundant faunal assemblages.</li> <li>▪ The deep sea floor covers an enormous area dominated by fine-grained sediments in a rather deep, cold, dark environment.</li> </ul>		<p>ecosystems.</p> <ul style="list-style-type: none"> <li>▪ Identify and remove invasive species in coastal ecosystems</li> </ul>

**UConn ECE Marine Science – H**  
**RESOURCES**

- An Introduction to the World’s Oceans, 9th edition. Sverdrup, Armbrust (ISBN 978-0-07-282701-9)

**PACING GUIDE**

Unit	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter
Unit 1: Introduction to Oceanography	X			
Unit 2: Introduction to Ocean Motion		X		
Unit 3: Introduction to Coastal Oceans			X	
Unit 4: Introduction to the Living Seas				X

## UConn ECE Marine Science – H Common Core Connections

### *ELA/Literacy*

- RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3, HS-PS1-5, HS-PS2-1, HS-PS2-6, HS-PS3-4, HS-PS4-2, HS-PS4-3, HS-PS4-4)
- RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-ETS1-3)
- RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1, HS-ETS1-3)
- WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6, HS-PS4-5)
- WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3, HS-PS2-5, HS-PS3-3, HS-PS3-4, HS-PS3-5)
- WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4, HS-PS3-5)
- WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2, HS-PS1-5)
- WHST.11-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.11-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3, HS-PS1-6, HS-PS2-1)
- WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the



## UCONN ECE MARINE SCIENCE – H COMMON CORE CONNECTIONS

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3, HS-PS2-5, HS-PS3-4, HS-PS3-5, HS-PS4-4)

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3, HS-PS2-1, HS-PS2-5)

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4, HS-PS3-1, HS-PS3-2, HS-PS3-5)

### ***Mathematics***

**MP.2** Reason abstractly and quantitatively. (HS-PS1-5, HS-PS1-7, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-ETS1-1, HS-ETS1-3, HS-ETS1-4)

**MP.4** Model with mathematics. (HS-PS1-4, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-PS4-1, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4)

**HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-1, HS-PS3-3)

**HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1, HS-PS2-4, HS-PS4-1, HS-PS4-3)

**HSA-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1, HS-PS2-2)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1, HS-PS2-2, HS-PS4-1, HS-PS4-3)

**HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

**HSS-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)