Washington Township School District

***The mission of the Washington Township Public Schools** is to provide a safe, positive, and progressive educational environment that provides opportunity for all students to attain the knowledge and skills specified in the NJ Learning Standards at all grade levels, so as to ensure their full participation in an ever-changing world as responsible, self-directed and civic-minded citizens.*

Course Title:	**Atmospheric and Space Science**
Grade Level(s):	**11-12**

Duration:	*Full Year:*	x	*Semester:*		*Marking Period:*	

Course Description:	**This course will focus on areas of meteorology, such as the structure of the atmosphere, controls of temperature, moisture, pressure systems, severe weather, and climate change, and on astronomy topics like observational astronomy, the earth-moon system, the solar system, and stellar evolution. Students will be exposed to real world topics like climate change, weather modification, weather prediction techniques, the space program, unmanned space exploration, and solar fusion as an energy source.**
Grading Procedures:	**Tests – 35%** **Quizzes – 20%** **Lab Work – 20%** **Projects – 15%** **Homework/Classwork – 10%**
Primary Resources:	**Lutgens/Tarbuck, <u>The Atmosphere</u>** **Next Generation Science Standards (NGSS)** **New Jersey Learning Standards (NJLS)**

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

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Under the Direction of:	Dr. Patricia Hughes

Written: ___August 2017_______________________________

Revised: ___________________________________

BOE Approval: ______________________________

Unit Title: Heating the Atmosphere

Unit Description: This unit will focus on the Earth's heat budget and local controls of temperature. The structure of the atmosphere will be examined and the effect of atmospheric gases like carbon dioxide will be discussed.

Unit Duration: 4 - 5 weeks

Desired Results

Standard(s):

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 systems.

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.

HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth

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's systems.

Indicators:

HS-ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

HS-ESS2.A: The geological record shows that changes to global and regional climate can be caused by 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.C: 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.D: 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.D: Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

HS-ESS2.D: Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

HS-ESS2.E: 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-ESS3.D: 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.D: 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.

Understandings:

Students will understand that…

- Earth's atmosphere has a differentiated structure with variations in composition and temperature changes
- Earth's atmosphere has changed over time
- Weather and climate are different areas of meteorology
- Seasonal variations in temperature are a result of Earth's angle of orientation relative to the sun
- Heat is transferred into and out of the atmosphere at different rates
- The global energy budget is affected by many Earth characteristics and in turns drives Earth's weather systems.
- Regional temperatures are controlled by characteristics like latitude, altitude, ocean currents, and geographic position.

Essential Questions:

1. What are the characteristics of the troposphere, stratosphere, mesosphere, and thermosphere?
2. How has Earth's atmosphere developed and changed?
3. How are weather and climate different?
4. How does insolation (energy from the sun) change over the course of a year?
5. What are the three methods of energy transfer and how does each lead to the heating of the Earth?
6. What are the components of the global energy budget and how does changing them affect the Earth's climate?
7. How do local controls of temperature affect the climate of a region?

Assessment Evidence

Performance Tasks:

- Diagram a model of the layers of the atmosphere including data on composition, pressure and temperature changes, and important structures
- Use a model to show how changes in the global energy budget affect the overall temperature of the Earth
- Predict seasonal temperature variations for a region, given geographic location

Other Evidence:

- Quizzes
  - Weather vs Climate
  - The Atmosphere
  - Heating the Atmosphere
- Lab Work
  - Vernier Lab – The Greenhouse Effect
  - Vernier Lab – Effect of Latitude on Heating
- Independent Work
  - Teacher Made Review Sheets
  - Read ch 1 – 3 and answer selected questions
  - Online Readings as listed with guided questions
  - Computer Activities
    - Energy Budget Simulation
    - Controls of Temperature Web Quest
  - Analysis/Problem Solving/Models
    - Weather vs Climate
    - Atmospheric Structure Analysis

	▪ Noon Sun Angles ▪ Environmental Lapse Rate Problems ▪ Temperature Data Analysis • Project ○ Climate Change News Report • Tests ○ One test at end of unit

Benchmarks:

Unit Test

Learning Plan

Learning Activities:

Lesson One – Introduction to Meteorology (1 Day)

Content – Elements of Weather and Climate; Difference between weather and climate

Reading - https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

Activity – Weather vs. Climate Statements Interpretation

Lesson Two – The Atmosphere (3-5 days)

Content – Structure, Composition, and History of the Atmosphere

Readings - http://okfirst.mesonet.org/train/meteorology/VertStructure.html; https://globalchange.umich.edu/globalchange1/current/lectures/Perry_Samson_lectures/evolution_atm/

Activities – Graphical Analysis of Atmospheric Structure; Environmental Lapse Rate Problems

Lesson Three – Heating the Atmsphere (4-6 days)

Content – Heat Radiation and Transfer; The Heat Budget

Readings - http://www.srh.noaa.gov/jetstream/atmos/heat.html; http://www.srh.noaa.gov/jetstream/atmos/energy.html

Activity –Vernier Lab – The Greenhouse Effect; Noon Sun Angles Analysis; Global Heat Budget Computer Simulation

Lesson Four – Temperature Variations (6 - 8 days)

Content – Controls of Temperature; Temperature Cycles; Applying Temperature Data

Readings - http://www.atmo.arizona.edu/students/courselinks/spring08/atmo336s1/courses/spring14/atmo170a1s1/lecture_notes/controls_temp/controls_temp_vers2.html; http://www.degreedays.net/introduction

Activity – Vernier Lab – Effect of Latitude on Heating; Controls of Temperature Web Quest; Temperature Data Analysis

Project

Students will research a climate change period of the past. Students will prepare an oral group presentation detailing the causes of, effects from, and changes in human history due to the climate change.

Resources:

- Lutgens, F. K., & Tarbuck, E. J. (2016). *The atmosphere: an introduction to meteorology* (13th ed.). Upper Saddle River, NJ: Pearson Education.
- Johnson, R. L., DeMoss, G. S., & Sorensen, R. (2007). *Earth science with Vernier: earth science experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.
- Dunbar, B. (2015, March 09). What's the Difference Between Weather and Climate? Retrieved July 21, 2017, from https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html
- Oklahoma Climatological Survey. (nd) Vertical Structure of the Atmosphere. (n.d.). Retrieved July 21, 2017, from http://okfirst.mesonet.org/train/meteorology/VertStructure.html
- Samson, P. (n.d.). Composition, Structure and Energy. Retrieved July 21, 2017, from https://globalchange.umich.edu/globalchange1/current/lectures/Perry_Samson_lectures/evolution_atm/
- National Weather Service. (n.d.). The Transfer of Heat Energy. Retrieved July 21, 2017, from http://www.srh.noaa.gov/jetstream/atmos/heat.html
- National Weather Service. (n.d.). The Earth-Atmosphere Energy Balance. Retrieved July 21, 2017, from http://www.srh.noaa.gov/jetstream/atmos/energy.html
- Novak, G. (2004). The Energy Budget Model. Retrieved July 21, 2017, from http://www.sciencecourseware.org/eec/GlobalWarming/EnergyBalance/index.html
- Controls of Temeperature. (n.d.). Retrieved July 21, 2017, from http://www.atmo.arizona.edu/students/courselinks/spring08/atmo336s1/courses/spring14/atmo170a1s1/lecture_notes/controls_temp/controls_temp_vers2.html
- Bromley, M. (n.d.). Degree Days. Retrieved July 21, 2017, from http://www.degreedays.net/introduction

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: Global Heating **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 systems. **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. **HS-ESS2-7:** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth **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's systems.	
4.0	**Students will be able to:** • **Create a rule to describe the changes in atmospheric temperature and pressure as one rises in the atmosphere** • **Use a computer model to predict changes in the global energy budget and global temperatures due to changes in carbon dioxide levels and/or albedo** • **Experimentally determine the effect of greenhouse gases on the temperature of a system** • **Research past climate changes and report on the cause and effect of the changes and offer comparisons to our current situation**
3.0	**Students will be able to:** • **Distinguish between statements of weather and statements of climate** • **Trace the development of the modern atmosphere** • **Predict temperatures aloft based on the environmental lapse rate** • **Graph temperature and pressure changes in the troposphere and stratosphere** • **Use soundings to predict the height of the troposphere** • **Differentiate between the types of heat transfer** • **Deduce changes in solar insolation during the course of a the year** • **Calculate noon sun angles for any location/date on Earth using an analemma**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: weather; climate; temperature; moisture; pressure; thermometer; hygrometer; barometer; anemometer; atmosphere; troposphere; stratosphere; ozone layer; mesosphere; thermosphere; ionosphere; environmental lapse rate; ellipse; aphelion; perihelion; noon sun angle; analemma; heat; conduction; convection; radiation; transmission; absorption; albedo; greenhouse effect; greenhouse gas; energy budget; degree day** • **Describe the current weather for a location** • **Describe the climate of an area** • **Select tools for measuring specific elements of weather** • **List the components of the modern atmosphere (composition)** • **List the layers of the modern atmosphere** • **Identify the temperature trend in each layer of the modern atmosphere**

	• **List the characteristics of each atmospheric layer** • **Summarize the parts of the global energy budget, highlighting inputs/outputs**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

STANDARDS: Controls of Temperature **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 systems. **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. **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's systems.	
4.0	**Students will be able to:** • **Predict local yearly temperature ranges based on geographic data** • **Trace the daily/annual temperature shifts for a location**
3.0	**Students will be able to:** • **Experimentally determine the effect of latitude on temperature** • **Explain how and why locations near bodies of water have a moderate temperature throughout the year compared to inland locations** • **Differentiate between east and west coast locations in terms of annual temperatures** • **Decide how albedo and/or cloud cover will affect the temperature of a location**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: climograph; specific heat capacity; differential heating; continentality; degree day** • **Use a climograph to find temperature/precipitation ranges** • **State the effect of latitude on temperature ranges** • **State the effect of altitude on temperature ranges** • **Compare the specific heat capacity of water to that of land** • **Identify warm and cold ocean currents** • **Calculate degree days**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities.

	• Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, Mastering Meteorology) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	• Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.

Interdisciplinary Connections

Indicators:
Common Core State Standards 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.
- 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.
- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- 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.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Moisture

Unit Description: This unit will focus on the role of water in Earth's weather. The state changes of water will be examined, as well as the differing types of measures of atmospheric moisture. Moisture's role in atmospheric stability and cloud formation will be discussed. Students will be expected to determine cloud formation levels. Processes forming precipitation will be described.

Unit Duration: 4-5 weeks

Desired Results

Standard(s):

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 systems.

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

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.

HS-ESS3.3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

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-ETS1.3: 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.

Indicators:

HS-ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

HS-ESS2.C: 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-ESS3.A: Resource av ailability has guided the development of human society.

HS-ESS3.B: 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-ETS1.A: C riteria and constraints also include satisfying any requirements set by society , such as taking issues of risk 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.

HS-ETS1.A: Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, w hich can be addressed through engineering. These global challenges also may hav e manifestations in local communities.

HS-ETS1.B: When ev aluating 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.	
Understandings: *Students will understand that…* • Water has unique properties that set it apart from other components of the atmosphere. • The hydrogen bonds that weakly hold water molecules together cause water to have a high specific heat capacity. • When water changes states, heat is exchanged with the surrounding environment. • Saturated air masses will cool/heat at different rates than unsaturated air masses due to this heat exchange. • Water vapor in the air can be expressed in several different ways – relative humidity being the most familiar. • Absolute humidity shows the amount of water vapor in a given volume of air; relative humidity compares the amount of water vapor to the amount the air can hold. • Warm air is capable of holding more water vapor than cold air. • Dew point is the best way to represent water vapor present in the air since it is not temperature dependent. • Rising air cools at the dry adiabatic rate until it reaches the lifted condensation level (LCL), whereupon it will cool at the wet adiabatic rate. Sinking air warms at the dry adiabatic rate continuously. • Air can be forcibly lifted by several processes. • Rainshadow deserts are formed when moist air encounters a mountain range and drops its moisture on one side of the range only. • Water vapor affects air stability and cloud formation. • Unstable air results from moist air that is heated at the surface and forced to rise. • Air stability is a major determinant of thunderstorm activity. • Clouds are classified based on appearance and height.	**Essential Questions:** 1. How does the shape of the water molecule affects its specific heat capacity? 2. What are the state changes that water undergoes and what energy changes correspond to those changes? 3. Why do saturated and unsaturated air masses heat/cool at different rates? 4. In what ways can water vapor in the atmosphere be represented? 5. How is absolute humidity different from relative humidity? 6. What happens to the relative humidity of an air mass as it cools? As it heats? 7. How can cool, dry air have a higher relative humidity than warm, moist air**?** 8. Why is dew point considered the superior measure of moisture content? 9. What happens to the temperature of an air mass as it rises/sinks in the atmosphere? 10. How can the level of cloud formation be predicted? 11. How can air be forced to rise? 12. What process produces rainshadow deserts? 13. How is unstable air produced and how does it react in the atmosphere? 14. What are the different types of cloud formations and how are they classified? 15. What processes produce fog? 16. How is precipitation formed in warm core clouds? In cold core clouds? 17. What are the different types of precipitation? 18. How have humans altered precipitation patterns?

• Fog is commonly formed by cooling air past its saturation point. • Two processes are responsible for the formation of precipitation – the Bergeron Process and collision-coalescence; the temperature of the clouds determines the type of process. • Humans have learned to modify precipitation patterns, both directly and indirectly.	

Assessment Evidence

Performance Tasks:

- Experimentally determine the latent heat of fusion of water
- Experimentally determine the relative humidity and dew point for a set of locations
- Graphically determine the Lifted Condensation Level (LCL)
- Classify clouds by height and appearance
- Trace the development of precipitation from cloud to ground
- Research and develop a pamphlet on the risks and benefits of weather modification programs, such as cloud seeding, cloud dispersal, hail suppression, etc.

Other Evidence:

- Quizzes
  - Measures of Atmospheric Moisture
  - Cloud Formation and Stability
  - Precipitation Formation
- Lab Work
  - Vernier Lab – Heat of Fusion
  - Relative Humidity and Dew Point
  - Cloud Formation
- Independent Work
  - Teacher Made Review Sheets
  - Read ch 4 & 5 and answer selected questions
  - Online Readings as listed with guided questions
  - Computer Activities
    - Cloud Formation Web Quest
  - Analysis/Problem Solving/Models
    - Humidity and Dew Point Problems
    - Adiabatic Lapse Rate Problems
    - Weather Modification Pamphlet
- Tests
  - One test at end of unit

Benchmarks:

Weather Modification Pamphlet

Learning Plan

Learning Activities:

Lesson One – Properties of Water (3 days)
Content – Structure of Water Molecule; Hydrogen Bonding; Phase Changes; Latent Heat
Reading – https://owlcation.com/stem/5-Properties-of-Water
Activity – Vernier Lab – Heat of Fusion

Lesson Two – Measures of Moisture (3 days)
Content – Humidity and Dew Point; Tools of Measuring Moisture
Reading – https://www.theweatherprediction.com/habyhints/190/
Activity – Relative Humidity and Dew Point Problem Solving; Relative Humidity and Dew Point Lab

Lesson Three – Lapse Rate and Air Stability (6 days)
Content – Adiabatic Lapse Rate; Lifting Air; Stability
Reading - http://www.cmmap.org/learn/clouds/lapseRate.html; http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec1/formation.html; http://www.ecoca.ro/meteo/tutorial/Weather/Older/Stability_of_Air.html
Activity – Lapse Rate Problem Solving; Cloud Formation Web Quest

Lesson Four – Clouds and Precipitation (8 days)
Content – Cloud Classification; Fog Formation; Precipitation Formation; Precipitation Classification; Weather Modification
Reading - https://weather.com/science/news/how-does-fog-form-20131010; http://weather.cod.edu/sirvatka/bergeron.html; https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/planned-weather-modification-through-cloud-seeding/; http://www.independent.co.uk/sport/olympics/how-beijing-used-rockets-to-keep-opening-ceremony-dry-890294.html
Activity – Cloud Formation Lab; Weather Modification Research and Pamphlet

Resources:

- Lutgens, F. K., & Tarbuck, E. J. (2016). *The atmosphere: an introduction to meteorology* (13th ed.). Upper Saddle River, NJ: Pearson Education.

- Johnson, R. L., DeMoss, G. S., & Sorensen, R. (2007). *Earth science with Vernier: earth science experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- L. (2016, June 13). 5 Properties of Water. Retrieved July 24, 2017, from https://owlcation.com/stem/5-Properties-of-Water

- Haby, J. (n.d.). Explaining Humidity and Dew Point. Retrieved July 24, 2017, from https://www.theweatherprediction.com/habyhints/190/

- Lapse Rate and Adiabatic Processes. (n.d.). Retrieved July 24, 2017, from http://www.cmmap.org/learn/clouds/lapseRate.html

- The atmosphere and the weather. (n.d.). Retrieved July 24, 2017, from http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec1/formation.html

- Stability of Air. (n.d.). Retrieved July 24, 2017, from http://www.ecoca.ro/meteo/tutorial/Weather/Older/Stability_of_Air.html

- Chambers, L. (n.d.). MY NASA DATA Lesson: - MY NASA DATA. Retrieved July 24, 2017, from https://mynasadata.larc.nasa.gov/lesson-plans/lesson-plans-hs-educators/?page_id=474%3F&passid=34

- Create a Portable Cloud. (n.d.). Retrieved July 24, 2017, from https://scied.ucar.edu/activity/create-portable-cloud

- Erdman, J. (2016, January 04). How Does Fog Form? Retrieved July 24, 2017, from https://weather.com/science/news/how-does-fog-form-20131010

- Sirvatka, P. (n.d.). The Bergeron Process. Retrieved July 24, 2017, from http://weather.cod.edu/sirvatka/bergeron.html

- American Meteorological Society. (n.d.). Retrieved July 24, 2017, from https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/planned-weather-modification-through-cloud-seeding/

- Coonan, C. (2008, August 10). How Beijing used rockets to keep opening ceremony dry. *The Independent*. Retrieved July 24, 2017, from http://www.independent.co.uk/sport/olympics/how-beijing-used-rockets-to-keep-opening-ceremony-dry-890294.html

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: ***This Goal refers to water's structure and its measurement in the atmosphere.*** **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 systems.** **HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**	
4.0	**Students will be able to:** • **Explain how the structure of the water molecule affects its specific heat capactity and latent heat** • **Research why evaporization (sweating) is a cooling process and how humidity affects sweating in humans** • **Defend the idea that dew point is a superior measure of atmospheric moisture**
3.0	**Students will be able to:** • **Experimentally determine the heat of fusion for water** • **Compare and contrast state changes for water in terms of energy** • **Compare and constrast absolute humidity, relative humidity, and dew point** • **Experimentally determine relative humidity and dew point for a location** • **Determine the conditions where changing relative humidity does not result in changing moisture content**
2.0	**Students will be able to:**

	• **Define the following terms in relation to meteorology: polarity; hydrogen bonding; heat of fusion; heat of vaporization; latent heat; condensation; vaporization; sublimation; deposition; absolute humidity; relative humidity; dew point; psychrometer** • **Diagram a water molecule and label the polarity** • **Diagram a hydrogen bond for water** • **List and identify the state changes of water** • **Describe the process of finding relative humidity and dew point** • **Identify the temperature of air that holds more moisture**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: ***This goal refers to water's affect on air masses in the atmosphere.*** **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 systems.** **HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** **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.** **HS-ESS3.3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.**	
4.0	**Students will be able to:** • **Predict the final temperature for an air mass rising over and descending down a mountain side and assess the effects that will have on the surrounding environments** • **Research how climate change will affect rainshadow deserts and their corresponding windward mountain ranges.** • **Evaluate atmospheric conditions to predict cloud formation altitudes**
3.0	**Students will be able to:** • **Determine the lifted condensation level for an air parcel** • **Differentiate between the wet and dry adiabatic lapse rates in terms of energy** • **Offer a rationale for the presence of temperate rainforests on one side of a mountain range and rainshadow deserts on the other** • **Evaluate whether a parcel of air will rise or sink based on stability** • **Compare and contrast the three types of air stability** • **Predict weather events based on air stability**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: adiabatic change; dry adiabatic lapse rate; wet adiabatic lapse rate; lifted condensation level (LCL); orographic lifting; frontal wedging; convergence; convective lift; rainshadow**

	desert; air mass thunderstorm; stability; absolute stability; absolute instability; conditional instability; level of free convection (LFC); lake-effect snow; inversion • Calculate temperature changes using the adiabatic lapse rates • List four ways an air parcel can be forcibly lifted • Diagram orographic lifting, frontal wedging, convergence, and convective lift • State the conditions for and outcomes of absolute stability • State the conditions for and outcomes of absolute instability • State the conditions for and outcomes of conditional instability • State the conditions required for an inversion layer
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

STANDARDS: ***This goal refers to the formation of clouds and precipitation.***

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 systems.

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

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.

HS-ESS3.3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

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-ETS1.3: 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.

4.0	**Students will be able to:** • Take a position on the use of weather modification techniques • Experimentally produce a "cloud" and determine the conditions necessary for cloud formation
3.0	**Students will be able to:** • Trace the development of a precipitation particle in both cold core and warm core clouds • Classify different types of "real world" clouds based on height and appearance • Compare and contrast the various ways fog can be formed • Compare and contrast the various forms of liquid and frozen precipitation in terms of formation processes • Evaluate the benefits and risks of weather modification for a region
2.0	**Students will be able to:** • Define the following terms in relation to meteorology: cirrus; stratus; cumulus; clouds of vertical development; condensation nuclei; Bergeron Process; collision-

	coalescence process; fog; advection; precipitation; weather modification; cloud seeding • **Describe low, middle, and high level clouds** • **Describe a cloud of vertical development** • **Identify different types of fog formations** • **List and identify different types of precipitation** • **Summarize common types of weather modification techniques**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, Mastering Meteorology) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete

	• Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	• Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.

Interdisciplinary Connections

Indicators:
Common Core State Standards 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.
- 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.
- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- 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.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

<u>Science & Engineering Practices</u>:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

<u>Cross-Cutting Connections:</u>
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

<u>Connections to Nature of Science:</u>
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Pressure Systems and Circulation

Unit Description: This unit will focus on pressure, wind, and global pressure systems. Pressure in the atmosphere at the microscale, mesoscale, and macroscale will be examined. Weather maps will be utilized to study and predict air flow patterns. Local winds (like sea and land breezes) will be investigated. Regional patterns like El Nino and the NAO (North Atlantic Oscillation) will also be introduced. Global patterns, such as the Coriolis Effect and Hadley Cells, will be discussed. The relation between circulation and climate patterns will be an integral part of this unit.

Unit Duration: 2-3 weeks

Desired Results

Standard(s):

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 systems.

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.

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.

HS-ESS3.3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

Indicators:

HS-ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

HS-ESS3.A: Resource availability has guided the development of human society.

HS-ESS3.B: 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-ETS1.A: Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, w hich can be addressed through engineering. These global challenges also may have manifestations in local communities.

HS-LS2.C: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. 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. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Understandings:

Students will understand that…

- Pressure weather maps are the most important weather charts used by meteorologists to predict weather changes.
- High pressure is associated with clear skies and low risk of precipitation; low pressure is associated with cloudy weather and a high risk of precipitation.
- Temperature, altitude, moisture content, and upper air disturbances all affect the pressure of an air mass.
- Wind is controlled by a combination of forces – the pressure gradient, Coriolis force, and friction.
- The Coriolis Effect is caused by the rotation of the Earth on its axis and causes the deflection of objects as they move toward/away from the poles.
- Low pressure areas (cyclones) will cause a counter-clockwise flow of air around them; high pressure areas (anti-cyclones) will cause a clockwise flow of air.
- Cyclones are areas with converging surface winds and diverging winds aloft; anti-cyclones have diverging surface winds and converging winds aloft.
- Local winds are small scale and are formed differential pressure due to heating/cooling.
- Earth’s troposphere circulates with a three “cell” pattern due to the vertical rising and falling of warm/cool air.

Essential Questions:

1. What is atmospheric pressure?
2. What weather conditions are associated with high pressure? With low pressure? Why?
3. How is pressure represented on a weather map?
4. Why do pressure maps indicate so much about current and future weather conditions?
5. How does the temperature of an air mass affect its pressure?
6. How does the moisture content of an air mass affect its pressure?
7. Why do upper air conditions affect pressure at the surface?
8. What forces create and affect wind?
9. What is the Coriolis Effect? How does it affect moving air masses in each hemisphere?
10. What happens to air around a low pressure system? Around a high?
11. What are four “local” winds and how is each produced?
12. How do local winds affect the weather/climate of a region?
13. Diagram the global circulation pattern for the Earth.
14. What is a Hadley cell and how does it function?
15. Why are the tropics associated with clear weather and “trade winds”?
16. What are the idealized pressure zones seen across the Earth? What weather is associated with each?
17. What is the “Bermuda High”? How does it form and how does it affect South Jersey?
18. What are monsoons? How do they form?

• Environmental conditions in latitude belts around the Earth are due, in part, to Hadley Cell circulation. • Large scale weather patterns are due to the formation of semipermanent pressure systems forming in specific areas of the globe. • Changing pressure system result in major shifts in world weather systems, ie – El Nino, the monsoons. • Ocean currents influence wind patterns and climate.	19. What causes the formation of El Nino? How does El Nino affect weather around the globe?

Assessment Evidence

Performance Tasks:
• Predict the production of a sea breeze based on differential heating
• Trace circulation patterns around the globe based on pressure systems
• Identify the causes of El Nino events using real data
	Other Evidence:
	• Quizzes
	  ○ Pressure
	  ○ The Coriolis Effect
	  ○ Local Winds
	  ○ Circulation
	• Lab Work
	  ○ Vernier Lab – Land and Sea Breezes
	  ○ Global Circulation
	• Independent Work
	  ○ Teacher Made Review Sheets
	  ○ Read ch 6 & 7 and answer selected questions
	  ○ Online Readings as listed with guided questions
	  ○ Computer Activities
	    ▪ El Nino Mapping Activity
	  ○ Analysis/Problem Solving/Models
	    ▪ The Coriolis Effect
	    ▪ Global Circulation Maps
	• Tests
	  ○ One test at end of unit

Benchmarks:

Unit Test

Learning Plan

Learning Activities:

Lesson One – Pressure and Weather Maps (1 day)
Content – Causes and Effects of Pressure; Measuring Pressure and Wind
Reading – http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec1/pres_effects.html
Activity – Demo – Heating and Wind

Lesson Two – Global Winds (3 days)
Content – Wind; The Coriolis Effect; Cyclones and Anticyclones
Reading – https://oceanservice.noaa.gov/education/kits/currents/05currents1.html
Activity – Coriolis Effect Activity

Lesson Three – Local Winds (3 days)
Content – Sea/Land Breezes; Mountain Breezes; Country Winds; Katabatic Winds
Reading - http://www.latimes.com/visuals/graphics/la-me-g-santa-ana-winds-listicle-htmlstory.html; http://www.weatheronline.co.uk/reports/wind/The-Bora.htm; https://www.washingtonpost.com/posttv/national/the-atlantic-city-windfarm-that-never-was/2015/03/29/e3b12eac-d4b1-11e4-8b1e-274d670aa9c9_video.html
Activity – Vernier Lab – Land and Sea Breezes

Lesson Four – Global Circulation Patterns (6 days)
Content – Hadley Cells; Global Pressure Zones; Seasonal Pressure Changes
Reading - http://www.srh.noaa.gov/jetstream/global/circ.html; https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1417.pdf; https://www.climate.gov/news-features/blogs/enso/what-el-ni%C3%B1o%E2%80%93southern-oscillation-enso-nutshell
Activity – Global Circulation Map; El Nino Mapping Computer Activity; Global Circulation Lab

Resources:

- Lutgens, F. K., & Tarbuck, E. J. (2016). *The atmosphere: an introduction to meteorology* (13th ed.). Upper Saddle River, NJ: Pearson Education.

- Johnson, R. L., DeMoss, G. S., & Sorensen, R. (2007). *Earth science with Vernier: earth science experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- The Atmosphere and the Weather. (n.d.). Retrieved July 27, 2017, from http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec1/pres_effects.html

- US Department of Commerce, National Oceanic and Atmospheric Administration. (2004, December 19). Currents. Retrieved July 27, 2017, from https://oceanservice.noaa.gov/education/kits/currents/05currents1.html

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- Weather Online. (n.d.). Bora. Retrieved July 27, 2017, from http://www.weatheronline.co.uk/reports/wind/The-Bora.htm

- N.J. clean energy project caught in cross winds. (2015, March 25). Retrieved July 27, 2017, from https://www.washingtonpost.com/posttv/national/the-atlantic-city-windfarm-that-never-was/2015/03/29/e3b12eac-d4b1-11e4-8b1e-274d670aa9c9_video.html

- US Department of Commerce, National Oceanic and Atmospheric Administration. (2005, December 19). NOAA National Ocean Service Education: Twisting the Air Away - The Coriolis Effect | Lesson Plan. Retrieved July 27, 2017, from https://oceanservice.noaa.gov/education/lessons/twisting_air_lesson.html

- National Weather Service. (n.d.). Global Circulations. Retrieved July 27, 2017, from http://www.srh.noaa.gov/jetstream/global/circ.html

- Crimmins, M. (2006, September). *Arizona and the North American Monsoon* (Publication No. AZ1417). Retrieved July 28, 2017, from Arizona Cooperative Extension website: https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1417.pdf

- L'Heureux, M. (2014, May 05). What is El Nino-Southern Oscillation (ENSO) in a nutshell? Retrieved July 28, 2017, from https://www.climate.gov/news-features/blogs/enso/what-el-ni%C3%B1o%E2%80%93southern-oscillation-enso-nutshell

- MY NASA DATA Lesson: - MY NASA DATA. (n.d.). Retrieved July 28, 2017, from https://mynasadata.larc.nasa.gov/lesson-plans/?page_id=474%3F&passid=57

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

STANDARDS: ***This goal refers to pressure and localized wind systems.***

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 systems.

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.

4.0	**Students will be able to:** • **Take a position on the development of "wind farms" at the Jersey Shore**
3.0	**Students will be able to:** • **Trace the development of a local wind system** • **Diagram the effect of the Coriolis "force" on a moving object** • **Compare and contrast high and low pressure systems in terms of air flow, weather production, and air aloft.** • **Research how local winds (like the Santa Ana) affect human society**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: pressure; barometer; isobar; pressure gradient force; Coriolis Effect; geostrophic wind; cyclonic flow; anticyclonic flow; low pressure system; high pressure system; anemometer; local wind; sea breeze; land breeze; mountain and valley breezes; katabatic winds; Chinook winds; country breezes**

	• State the factors that contribute to high atmospheric pressure • Describe the effects of high/low atmospheric pressure on the human body • Identify a local wind system
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: ***This goal refers to global pressure systems.*** **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 systems.** **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.** **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.** **HS-ESS3.3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.**	
4.0	**Students will be able to:** • Test the formation of global circulation using water of differing temperatures • Using real satellite data, predict the formation of El Nino/La Nina in the Pacific Ocean and examine the effects each has on the global climate and human society • Take a position on the statement "Weather patterns on the Earth can best be understood be examining pressure systems".
3.0	**Students will be able to:** • Trace the circulation of air around the globe • Compare and contrast the global pressure zones • Differentiate between a single cell circulation globe and the "real" triple cell circulation in terms of development and effects • Predict regional weather trends based on the location of permanent and semipermanent pressure systems • Create an analogy between the formation of the Indian Ocean Monsoon and the North American Monsoon
2.0	**Students will be able to:** • Define the following terms in relation to meteorology: circulation; Hadley cell; Ferrell cell; trade winds; westerlies; polar cell; easterlies; equatorial low; intertropical convergence zone (ITCZ); subtropical high; polar high; subpolar low; semipremanent pressure systems; Bermuda High; Icelandic low; monsoon; jet streams; upwelling; El Nino; La Nina; • Summarize the relationship between pressure and precipitation formation • Explain the formation of jet streams • Relate ocean currents to air circulation • Identify permanent and semipermanent pressure zones on the Earth • Describe the production of a monsoon

1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
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Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
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English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
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- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
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Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Air Masses and Fronts

Unit Description: This unit will focus on the air masses that affect North America and the weather systems that result from them. Students will compare the different types of fronts that result from the interaction of these air masses. The production of mid-latitude cyclones and the associated weather will be examined.

Unit Duration: 2-3 weeks

Desired Results

Standard(s):

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 systems.

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.

Indicators:

HS-ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

HS-ESS3.B: 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.

Understandings:

Students will understand that…

- Air masses are large bodies of air characterized by a common temperature and moisture content.
- When an air mass moves from its source zone, it carries the characterisitcs of that area to a new zone.
- North America is affected by five air masses – cA, cP, mP, mT, cT.
- When air masses of different characteristics meet, a front forms between them.
- Warms fronts occur when warm, moist air rides up over colder, dry air.
- Cold fronts occur when colder air forces itself into a region, displacing warmer air.
- Warm fronts are associated with light to moderate widespread precipitation, whereas cold fronts are associated with localized stormy weather.
- Occulded fronts occur when a fast moving cold front overtakes a warm front; these cause variable weather conditions.

Essential Questions:

1. What is an air mass?
2. What air masses typically affect North America?
3. What are the typical zones of air mass formation?
4. What happens to an air mass as it moves over a new surface?
5. How can an air mass become modified?
6. What are the characteristics associated with each air mass?
7. How do fronts form?
8. What are the characteristics of warm and cold fronts?
9. How are occulded fronts formed?
10. What is a mid-latitude cyclone?
11. How is a mid-latitude cyclone formed?
12. Where do mid-latitude cyclones typically form over North America?
13. Describe the surface circulation of a mid-latitude cyclone in North America.
14. What causes the dissipation of a mid-latitude cyclone?
15. What is the typical weather associated with a mid-latitude cyclone that strikes New Jersey?

- Mid-latitude cyclones are formed by a process known as cyclogenesis – a six staged process involving a clash of air masses along the polar front. - A mature mid-latitude cyclone takes on a characteristic comma shape around a low pressure center, with a warm sector sandwiched between a connected warm and cold front. - Mid-latitude cyclones can form in several areas over North America; the zone of formation indicates the type and severity of the storm. - A nor’easter is a mid-latitude cyclone that forms along either the east coast or Gulf of Mexico; these storms are a major weather maker for South Jersey. - In a typical winter mid-latitude nor’easter, a variety of weather conditions are reported, starting with snow then changing to rain as the warm sector is encountered. There is then a sudden, severe drop in temperatures with intense snow and wind (blizzard conditions) as the cold front passes. The storm end with bitterly cold temperatures and high winds from the northeast as it pulls away.	
Assessment Evidence	
Performance Tasks: - Design and interpret a weather map to identify air masses - Use a weather map to identify fronts and predict weather conditions for those areas around the front - Issue a weather bulletin for a region based on a weather map	**Other Evidence:** - Quizzes - Air Masses - Fronts - Lab Work - Weather Maps - Mid-Latitude Cyclones - Independent Work - Teacher Made Review Sheets - Read ch 8 & 9 and answer selected questions - Online Readings as listed with guided questions - Computer Activities - Air Masses and Fronts Web Quest - Analysis/Problem Solving/Models - Air Mass Map - Tests - One test at end of unit

Benchmarks:

Unit Test

Learning Plan

Learning Activities:

Lesson One – Identifying Air Masses (3 days)
Content – Air Mass Regions; Air Mass Characteristics; Air Mass Modifications
Reading – http://geo.msu.edu/extra/geogmich/air_masses.html
Activity – Air Mass Map; Air Masses and Fronts Web Quest

Lesson Two – Fronts (4 days)
Content – Types of Fronts; Weather Associated with Fronts; Weather Maps
Reading – http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/af/frnts/home.rxml
Activity – Weather Map Lab

Lesson Three – Mid-Latitude Cyclones (5 days)
Content – Formation of Mid-Ltitude Cyclones; Weather Associated with Mid-Latitude Cyclones
Reading - http://sciencing.com/stages-midlatitude-cyclones-8454789.html; http://climate.ncsu.edu/edu/k12/.mlc
Activity – Mid-Latitude Cyclone Lab; Video – Nor'easter: Killer Storms

Resources:

- Lutgens, F. K., & Tarbuck, E. J. (2016). *The atmosphere: an introduction to meteorology* (13th ed.). Upper Saddle River, NJ: Pearson Education.
- Schaetzl, R. (n.d.). Air Masses. Retrieved July 30, 2017, from http://geo.msu.edu/extra/geogmich/air_masses.html
- Fronts. (n.d.). Retrieved July 30, 2017, from http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/af/frnts/home.rxml
- National Weather Service. (n.d.). Learning Lesson: Drawing Conclusions. Retrieved July 30, 2017, from http://www.srh.noaa.gov/jetstream/synoptic/ll_analyze.html
- Tarbuck, E. J., Tasa, D., & Lutgens, F. K. (2011). *Instructor resource center on DVD Foundations of earth science, 6th ed. Lutgens, Tarbuck, Tasa*. Upper Saddle River, NJ: Prentice Hall.

- Towers, J. (Producer). (2000). *Nor'easter - Killer Storms* [Video file]. USA: History Channel. Retrieved July 30, 2017, from https://youtu.be/2u1nqMlMXwM

- Kramer, M. (2017, April 25). The Stages of Mid-Latitude Cyclones. Retrieved July 30, 2017, from http://sciencing.com/stages-midlatitude-cyclones-8454789.html

- Mid-Latitude Cyclones. (2013, August 9). Retrieved July 30, 2017, from http://climate.ncsu.edu/edu/k12/.mlc

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

STANDARDS: ***This goal refers to air masses and fronts.***

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 systems.

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.

4.0	**Students will be able to:** • **Predict weather conditions by creating and analyzing an isobar weather map** • **Investigate the formation and hazards associated with lake effect snow**
3.0	**Students will be able to:** • **Compare and contrast air masses of various source regions** • **Deduce the characteristics of an air mass based on its source region** • **Compare and contrast warm and cold fronts in terms of formation and associated weather conditions**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology:air mass; continental Arctic; continental polar; maritime polar; continental tropical; maritime tropical; modified air mass; lake effect snow; front; cold front; warm front; stationary front; occulded front; dryline** • **Identify an air mass using the taxonomic system** • **Draw isolines to connect points of equal weather condition (pressure, temperature, dew point, etc)** • **Identify a warm/cold/occulded front on a weather map**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

STANDARDS: ***This goal refers to mid-latitude cyclones.***

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 systems.

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.	
4.0	**Students will be able to:** • **Investigate the effects of a real world mid-latitude cyclone on the South Jersey area** • **Predict the weather associated with a mid-latitidue cyclone based on a weather map of the local conditions**
3.0	**Students will be able to:** • **Trace the development of a mid-latitude cyclone as it moves across North America** • **Compare and contrast Alberta Clippers and Nor'easters** • **Summarize the weather associated with a mid-latitude cyclone over the United States in winter**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: mid-latitude cyclone; polar front theory; cyclogenesis; Alberta Clipper; Nor'easter** • **List the stages of development for a mid-latitude cyclone**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, Mastering Meteorology) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to

	access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	• Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.

Interdisciplinary Connections

Indicators:
Common Core State Standards 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.
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- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
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- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Severe Weather

Unit Description: This unit will focus on severe weather – thunderstorms, tornadoes, and hurricanes. The formation of simple (air mass) thunderstorms and severe thunderstorms will be examined. Lightning and lightning safety will be introduced. Tornado formation, tornado effects and prediction will be examined. Tropical weather will also be covered in detail. Predictiom techniques will be examined. A project will be included and will focus on various types of severe weather, not just those covered in this unit.

Unit Duration: 3 – 4 weeks

Desired Results

Standard(s):

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 systems.

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.

Indicators:

HS-ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

HS-ESS3.B: 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.

Understandings:

Students will understand that…

- Thunderstorm form when warm, humid air rises in an unstable environment.
- A number of mechanisms can trigger the upward air movement of air needed to produce a thunderstorm cloud.
- In the coming decades, due to climate change, thunderstorm formation will likely be enhanced, especially along the south and east coast of the United States.
- Air-mass thunderstorms occur frequently in maritime tropical air during the spring and summer.
- There are three stages to the development of an air-mass storm: cumulus, mature, and dissipating.
- Updrafts and downdrafts are vital to thunderstorm development.
- Severe thunderstorms are capable of producing high winds, heavy downpours, and hail.
- Supercell thunderstorms are extremely dangerous and may produce tornadoes.

Essential Questions:

1. How do thunderstorms form?
2. What causes air to rise?
3. How will climate change affect the formation and effects from thunderstorms?
4. What are the stages in the development of an air mass thunderstorm?
5. How do updrafts and downdrafts contribute to thunderstorm development?
6. How is a serve thunderstorm different from an air mass thunderstorm?
7. How are severe thunderstorms formed?
8. What types of conditions are assiociated with severe thunderstorms?
9. What causes lightning to form?
10. What is the typical shape of a lightning bolt?
11. How does lightning travel?
12. What causes thunder?
13. What is a tornado?
14. How do tornadoes form?
15. What kinds of effects are seen in tornadoes?
16. How are tornadoes rated?
17. Where are tornadoes most common?

• Lightning in a storm is produced by separation of charges. • Lightning may be cloud to cloud or ground to ground. • Thunder is produced by the lightning bolt superheating the air, causing it to expand faster than the speed of sound. • A tornado is a violent windstorm that takes the form of a rotating column of air. • Wind speeds in a tornado can reach 300 miles/hour. • Tornadoes are rated on a scale known as the Fujita Scale. • Severe thunderstorms and tornadoes are difficult to forecast precisely because of their small scale. • Hurricanes are intense centers of low pressure that form over warm oceans in tropics. They must have sustained winds of 74 mph. • The profile of a typical hurricane is a steep pressure gradient that generates a rapid, inward spiral of winds. • At the center of a hurricane is a formation called the eye, which is normally precipitation free with low winds. • Hurricanes mostly form in late summer when ocean temperatures are near their maximum and can generate heat and moisture to the air. • Hurricanes begin as tropical disturbances which progress to form tropical storms. • Hurricanes diminish in intensity when they move over cool water, moe over land, or when conditions aloft are unfavorable. • Hurricanes are ranked on a scale known as the Saffir-Simpson scale. • Hurricane destruction comes in many forms – storm surge, wind, and flooding. • Hurricane watches and warnings are provided by the National Hurricane Center to alert the public to potential hazards.	18. What is a hurricane? 19. What is needed for a hurricane to form? 20. What is the typical structure of a hurricane? 21. What conditions are typically seen in the eye of a hurricane? 22. When and where do hurricanes form? 23. How are hurricanes named? 24. What causes hurricanes to dissipate? 25. What types of hazards are associated with hurricanes? 26. What is the National Hurricane Center's role in forecasting hurricanes?

Assessment Evidence

Performance Tasks:	**Other Evidence:**

• Diagram the structure of a thunderstorm and hurricane
• Develop a safety poster for thunderstorm/lightning/hurricane safety
• Create a weather forecast for a past natural disaster using researched data
	• Quizzes
	  ○ Thunderstorms
	  ○ Tornadoes
	  ○ Tropical Systems
	• Lab Work
	  ○ Upper Air Soundings
	• Independent Work
	  ○ Teacher Made Review Sheets
	  ○ Read ch 10 & 11 and answer selected questions
	  ○ Online Readings as listed with guided questions
	  ○ Computer Activities
	    ▪ Aim a Hurricane Simulation
	    ▪ Tornado Damage Simulation
	  ○ Analysis/Problem Solving/Models
	    ▪ Hurricane Graphing Analysis
	• Tests
	  ○ One test at end of unit
	• Project
	  ○ Weather Disaster Project

Benchmarks:

Mid-term is scheduled at the end of this unit

Learning Plan

Learning Activities:

Lesson One – Thunderstorms (5 days)
Content – Air Mass vs Severe Thunderstorm Formation; Thunderstorm Forecasting; Hazards from Thunderstorms; Lightning
Reading – http://www.nssl.noaa.gov/education/svrwx101/thunderstorms/; http://www.nssl.noaa.gov/education/svrwx101/thunderstorms/faq/; http://www.nssl.noaa.gov/education/svrwx101/lightning/faq/
Activity – Video – Lightning!; Upper Air Soundings Lab

Lesson Two – Tornadoes (3 days)
Content – Tornado Formation and Forecasting; Tornado Hazards
Reading – http://www.nssl.noaa.gov/education/svrwx101/tornadoes/; http://www.nssl.noaa.gov/education/svrwx101/tornadoes/types/; http://www.nssl.noaa.gov/education/svrwx101/tornadoes/detection/;
Activity – Tornado Damage Simulation; Tornado in a Bottle Demonstration

Lesson Three – Tropical Systems (5 days)

Content – Hurricane Structure and Formation; Hurricane Behavior; Hurricane Hazards; Hurricane Forecasting

Reading - http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/stages/home.rxml; http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/damg/home.rxml; http://www.history.com/topics/hurricane-katrina

Activity – Hurricane Graphing Analysis; Aim a Hurricane Simulation; Safety Poster; Video – Seconds from Disaster – Hurricane Katrina

Resources:

- Lutgens, F. K., & Tarbuck, E. J. (2016). *The atmosphere: an introduction to meteorology* (13th ed.). Upper Saddle River, NJ: Pearson Education.

- Tarbuck, E. J., Tasa, D., & Lutgens, F. K. (2011). *Instructor resource center on DVD Foundations of earth science, 6th ed. Lutgens, Tarbuck, Tasa*. Upper Saddle River, NJ: Prentice Hall.

- Thunderstorm Basics. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

- Thunderstorm FAQ. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/thunderstorms/faq/

- Lightning FAQ. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/lightning/faq/

- NOVA; Lightning!. Boston, MA: WGBH Media Library & Archives. Retrieved from http://openvault.wgbh.org/catalog/V_C33085B424B1465FB45CA5B6B75FEADF

- Tornado Basics. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/tornadoes/

- Tornado Types. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/tornadoes/types/

- Tornado Detection. (n.d.). Retrieved August 03, 2017, from http://www.nssl.noaa.gov/education/svrwx101/tornadoes/detection/

- SciJinks It's all about weather! (n.d.). Retrieved August 03, 2017, from https://scijinks.gov/tornado-simulation/

- Stages of Tropical Development. (n.d.). Retrieved August 03, 2017, from http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/stages/home.rxml

- Damage due to hurricanes. (n.d.). Retrieved August 03, 2017, from http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/damg/home.rxml

- History.com Staff. (2009). Hurricane Katrina. Retrieved August 03, 2017, from http://www.history.com/topics/hurricane-katrina

- Whitehurst, C. (2002). Aim a Hurricane Simulator. Retrieved August 03, 2017, from http://www.nhc.noaa.gov/outreach/games/movncane.htm

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STANDARDS: **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 systems.** **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.**	
4.0	**Students will be able to:** • **Investigate the effects of a real world severe weather event and create a weather bulletin to warn the public about the event** • **Examine a weather product (radar) and determine the type of severe weather occurring**
3.0	**Students will be able to:** • **Trace the development of thunderstorms** • **Compare and contrast the basic types of thunderstorms** • **Trace the development of a cloud to ground lightning bolt** • **Determine the relationship between tornado width, pressure difference, and damage** • **Trace the development of a tropical system from depression to hurricane and back to depression** • **Determine the factors that affect the development of a tropical system and its track**
2.0	**Students will be able to:** • **Define the following terms in relation to meteorology: thunderstorm; air-mass thunderstorm; severe thunderstorm; supercell; updraft; downdraft; gust front; lightning; step leader; roll cloud; cumulonimbus tower; anvil; mesocyclone; straight-line wind (derecho); bow echo; hook echo; couplet; tornado; Fujita Scale; tropical depression; tropical storm; hurricane; eye; eye wall; storm surge; feeder bands; watch; warning; Saffir-Simpson Scale** • **List the stages of an air mass thunderstorm** • **Diagram the development of an air mass thunderstorm** • **Diagram the structure of a tropical system** • **Describe a lightning bolt** • **Identify the hazards associated with a hurricane** • **Identify areas at threat from tornadoes** • **Describe rating scales for tornadoes and tropical systems** • **Identify locations at threat from tropical systems**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**

0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
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Cause and Effect

Connections to Nature of Science:
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Unit Title: The Earth-Moon System

Unit Description: This unit will introduce the astronomy portion of the course. Students will start with a brief introduction to observational astronomy and the importance of astronomy in the ancient world. A project will focus on an ancient observational structure from around the world (like Stonehenge). Modern tools of observation will be introduced. Students then look at the structure and formation of the moon, concentrating on lunar geology. A computer lab will introduce lunar motion – phases, eclipses and tides.

Unit Duration: 4-5 weeks

Desired Results

Standard(s):

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-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.

Indicators:

HS-ESS1.C: Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, 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

Understandings:

Students will understand that…

- Astronomy is a modern science with roots in the ancient world, the influence of which can still be seen today.
- Modern tools like telescopes and space-based observatories have strengthed our knowledge of both the Earth and the universe.
- The moon formed from a major collision with the yound Earth in the early solar system.
- The moon has a variety of surface features formed by both volcanic and impact origins.
- The moon's phases are caused by the moon's motion around the Earth.
- Eclipses do not occur every month due too the difference in the moon's plane of orbit about the Earth.
- The pull of the moon on the Earth casues tides, the height of which is affected by the lunar phase.

Essential Questions:

1. What was the importance of astronomy in the ancient world?
2. How did ancient people use the sky as part of their civilization?
3. What tools do modern astronomers use to study the universe?
4. What are the strengths and weaknesses of the major lunar formation models?
5. Why is the Giant Impact Model the accepted model of lunar formation?
6. What surface features are found on the moon and how were they created?
7. How does the interior of the moon compare to the interior of the Earth?
8. Diagram the moon's phases.
9. Explain the causes of the changing appearance of the moon each night.
10. What are the different types of eclipses and how does each form?
11. What causes tides?
12. How do tides change during the course of a lunar cycle?

Assessment Evidence

Performance Tasks:	**Other Evidence:**

• Research and develop a presentation on an ancient astronomical site.
• Develop an argument for additional space-based observatories (like the Hubble).
• Track the lunar motion around the Earth and relate it to the phases seen on the Earth.
	• Quizzes
	  ○ Observational Astronomy
	  ○ Lunar Formation Theories
	  ○ Lunar Geology
	  ○ Lunar Phases
	• Lab Work
	  ○ Lunar Phases
	  ○ Refracting Telescopes (pending equipment)
	• Independent Work
	  ○ Teacher Made Review Sheets
	  ○ Online Readings as listed with guided questions
	  ○ Computer Activities
	    ▪ Lunar Geology Identification
	    ▪ Lunar Motion (Starry Night Software)
	  ○ Analysis/Problem Solving/Models
	    ▪ Lunar Phase Problems
	• Tests
	  ○ One test at end of unit
	• Project
	  ○ Ancient Astronomy Site Presentation

Benchmarks:

Unit Test

Project

Learning Plan

Learning Activities:

Lesson One – Observational Astronomy (6-8 days)
Content – Astronomy in the Ancient World; Tools of the Astronomer
Reading – http://www.astronomy.com/~/media/import/files/pdf/8/6/c/august_2010_we_stargazing-in-ancient-egypt.pdf; https://www.space.com/21925-james-webb-space-telescope-jwst.html
Activity – Project – Ancient Astronomy Sites; Refracting Telescope Lab (pending); Video – Constellations and Ancient Astronomy; Video – Hubble's Amazing Universe

Lesson Two – Lunar Formation and Structure (4-5 days)
Content – Lunar Formation Models; Lunar Interior; Lunar Geology
Reading – https://starchild.gsfc.nasa.gov/docs/StarChild/questions/question38.html; https://www.space.com/55-earths-moon-formation-composition-and-orbit.html
Activity – Lunar Geology Computer Activity; Video – If We Had No Moon

Lesson Three – Lunar Motions (5-7 days)
Content – Phases of the Moon; Eclipses; Tides
Reading - https://www.livescience.com/32671-whats-a-solar-eclipse.html
Activity – Lunar Phases Lab; Lunar Motion Computer Activity; Lunar Phase Problem Solving; Lunar Observations (if timing matches class period)

Resources:

- Gary, P. B., & Talcott, R. (2010, August). Star-Gazing in Ancient Egypt. *Astronomy*, 63-67.
- Howell, E. (n.d.). James Webb Space Telescope: Hubble's Cosmic Successor. Retrieved August 03, 2017, from https://www.space.com/21925-james-webb-space-telescope-jwst.html
- Spaulding, N. (1994). *Earth Science Laboratory Investigations*. Lexington, MA: DC Heath & Co.
- The Universe: Constellations and Ancient Civilizations. (2015). USA. Retrieved August 03, 2017, from https://youtu.be/y12etYM0L90
- Television Program – Hubble Deep Field. (2015). USA: National Geographic Channel. Retrieved August 03, 2017, from https://youtu.be/vY9H7zAofmA
- Choi, C. Q. (2014, November 19). Moon Facts: Fun Information About the Earth's Moon. Retrieved August 03, 2017, from https://www.space.com/55-earths-moon-formation-composition-and-orbit.html
- Dejoie, J., & Trulove, E. (n.d.). Where did the moon come from? Retrieved August 03, 2017, from https://starchild.gsfc.nasa.gov/docs/StarChild/questions/question38.html
- Hawii Space Grant Consortium. (n.d.). Lunar Landforms Activity. Retrieved August 03, 2017, from http://www.spacegrant.hawaii.edu/class_acts/LunarLandformsTe.html
- If We Had No Moon. (1999). USA: The Science Channel. Retrieved August 03, 2017, from https://youtu.be/ZOHltB-kLGA
- Chow, D. (2017, June 23). What Is a Solar Eclipse? Retrieved August 03, 2017, from https://www.livescience.com/32671-whats-a-solar-eclipse.html

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

STANDARDS:

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.

4.0	**Students will be able to:** • **Investigate structures designed by ancient humans built to act as observatories and calendars** • **Develop an argument in support of funding for space-based observatories**
3.0	**Students will be able to:**

	• **Deduce the importance of astronomy to ancient civilizations** • **Compare and contrast reflecting and refracting telescopes** • **Form a conclusion about the importance of space-based observatories**
2.0	**Students will be able to:** • **Define the following terms in relation to astronomy: calendrical structure; constellation; refracting telescope; reflecting telescope; interferometer; space-based observatory** • **List the importance of astronomy in the ancient world** • **Identify tools used by astronomers to study the universe** • **Recognize discoveries made with modern astronomical tools**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: **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.**	
4.0	**Students will be able to:** • **Decide which model of lunar formation is the most likely based on evidence collected by NASA missions** • **Explain how Earth and the moon have similar surface features use different internal structures** • **Predict lunar phases based on lunar position around the Earth**
3.0	**Students will be able to:** • **Compare and contrast the lunar formation models** • **Judge the appearance of lunar features and identify the features as impact or volcanic in origin** • **Experimentally determine the cause of the phases of the moon** • **Compare and contrast lunar and solar eclipses** • **Explain the importance of Earth's moon to the stability of our planet**
2.0	**Students will be able to:** • **Define the following terms in relation to astronomy: fission (daughter) model; co-accretion (twin) model; capture model; giant impactor model; maria; highlands; ray; rille; crater; phase; synchronous rotation; eclipse; solar eclipse; lunar eclipse; annular eclipse; planet transit; spring tide; neap tide** • **Describe how the Giant Impactor model explains similarities and differences in the Earth and moon** • **Describe the appearance of the luanr surface** • **Describe the changing appearance of the moon during the course of the month** • **Describe the appearance of a solar eclipse** • **Describe the appearance of a lunar eclipse**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, Mastering Meteorology) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	• Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans

Interdisciplinary Connections

Indicators:
Common Core State Standards 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.
- 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.
- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- 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.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data

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

<u>Cross-Cutting Connections:</u>
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

<u>Connections to Nature of Science:</u>
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: The Solar System

Unit Description: This unit will describe Earth's place among the planets of the solar system. It will begin with a description of Kepler's Laws of Planetary Motion and a discussion of historical perspectives of the heliocentric model. Students will then examine the solar nebula hypothesis of solar system formation. A discussion of individual planets and planetoids will be a major focus.

Unit Duration: 4-5 weeks

Desired Results

Standard(s):

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

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.

Indicators:

HS-ESS1.B: 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.C: Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, 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

Understandings:

Students will understand that…

- The orbits of the planets are ellipses with the sun at one focus.
- Planets move fastest when closest to the sun and slowest when furthest.
- A planet's period is a function of its distance to the sun.
- The heliocentric model replaced the geocentric model to describe planetary motion.
- The solar nebula hypothesis explains the major characteristics of the solar system.
- The solar system developed from a rotating cloud of gas and dust through a process known as accetion.
- The inner planets are dense, rocky, and small due to intense heating during the early phase of the planet building.
- The outer planets are low dense; gaseous/icy, large, and with rings due to lack of heating in that part of the solar system.
- Planetoids include ice dwarfs, asteroids, meteors, and comets.

Essential Questions:

1. What are Kepler's Laws of Planetary Motion?
2. How do Kepler's Laws explain the motion of the planets?
3. What evidence supported the heliocentric model over the geocentric model?
4. How did the solar system form and how did it take on the characteristics it has today?
5. Describe the features of the terrestrial planets. Why do they have those features?
6. Describe the features of the Jovian planets. Why do they have those features?
7. How are moons of the Jovian planets unique?
8. What are the characterisitcs of the ice dwarfs?
9. How are asteroids and comets different? How are both evidence of the early solar system?
10. How have unmanned missions increased our knowledge of the solar system?

• The ice dwarfs are found in a region known as the Kuiper Belt; Pluto is one example of an ice dwarf. • Asteroids are found in several distinct regions of the solar system; they are rocky remains from the early solar system. • Comets come from two regions – the Kuiper Belt and the Oort Cloud; they have highly elliptical orbits. • Unmanned missions to the planets have contributed greatly to our knowledge of the solar system.	

Assessment Evidence

Performance Tasks:

- Determine the period/distance from the sun of a planet based on Kepler's Laws.
- Trace the development of the solar system.
- Compare the terrestrial and Jovian planets.
- Debate the inclusion/exclusion of Pluto as a planet.

Other Evidence:

- Quizzes
  - Kepler's Laws
  - Solar Nebula Hypothesis
  - Terrestrial Planets
  - Jovian Planets
  - Planetoids
- Lab Work
  - Elipses
  - Density of Solar System Objects
- Independent Work
  - Teacher Made Review Sheets
  - Online Readings as listed with guided questions
  - Computer Activities
    - Kepler's Laws
    - Solar System Builder
    - Planetary Collisions
  - Analysis/Problem Solving/Models
    - Kepler Problems
    - Moons of Jupiter
- Tests
  - One test at end of unit

Benchmarks:

Unit Test

Learning Plan

Learning Activities:

Lesson One – Solar System Dynamics (4 - 6 days)
Content – Heliocentric Model; Kepler's Laws; Solar Nebula Hypothesis
Reading – https://www.atnf.csiro.au/outreach/education/senior/astrophysics/galileo.html; http://www.physicsclassroom.com/class/circles/Lesson-4/Kepler-s-Three-Laws; https://www.universetoday.com/38118/how-was-the-solar-system-formed/
Activity – Lab – Ellipses; Computer Simulation – Kepler's Laws

Lesson Two – The Planets (6 - 8 days)
Content – Terrestrial Planets; Jovian Planets
Reading – https://www.nasa.gov/feature/goddard/2016/nasa-climate-modeling-suggests-venus-may-have-been-habitable; https://www.space.com/37722-mars-rover-curiosity-five-years-anniversary.html; https://www.nasa.gov/feature/jpl/cassini-explores-a-methane-sea-on-titan; https://www.nasa.gov/press-release/all-systems-go-for-nasas-mission-to-jupiter-moon-europa
Activity – Lab – Density of Solar System Objects; Computer Simulation – Solar System Builder; Moons of Jupiter Analysis; Video – The Planets: Giants

Lesson Three – The Planetoids (4 - 6 days)
Content – The Ice Dwarfs; Asteroids; Comets; Meteors
Reading - https://www.space.com/12692-dwarf-planets-solar-system-tour.html; http://www.popularmechanics.com/space/a17822/the-asteroid-hunters/;
Activity – Video – Bye, Bye Planet Pluto; Video – Killer Asteroids; Demo – Cooking Up a Comet; Planetary Collisions Simulation

Resources:

- Ellipses Lab. (n.d.). Retrieved August 6, 2017, from https://www.cbsd.org/cms/lib/PA01916442/Centricity/Domain/1908/Ellipse%20lab.pdf

- PhET Interactive Simulations. (n.d.). Retrieved August 06, 2017, from https://phet.colorado.edu/

- Galileo and the Telescope. (n.d.). Retrieved August 6, 2017, from https://www.atnf.csiro.au/outreach/education/senior/astrophysics/galileo.html

- Kepler's Three Laws. (n.d.). Retrieved August 06, 2017, from http://www.physicsclassroom.com/class/circles/Lesson-4/Kepler-s-Three-Laws

- Williams, M. (2016, July 19). How Was the Solar System Formed? - The Nebular Hypothesis. Retrieved August 06, 2017, from https://www.universetoday.com/38118/how-was-the-solar-system-formed/

- Solar System Builder. (n.d.). Retrieved August 06, 2017, from http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf%3A%3A800%3A%3A600%3A%3A%2Fsites%2Fdl%2Ffree%2F0072482621%2F78780%2FSolar_Nav.swf%3A%3ASolar System Builder

- McNabb, D. (Director). (1999). *The Planets: Giants* [Motion picture on DVD]. USA: The Discovery Channel.

- Spaulding, N. (1994). *Earth Science Laboratory Investigations*. Boston, MA: DC Heath & Co.

- Garner, R. (2016, August 11). Venus May Once Have Been Habitable. Retrieved August 06, 2017, from https://www.nasa.gov/feature/goddard/2016/nasa-climate-modeling-suggests-venus-may-have-been-habitable

- Wall, M. (2017, August 5). After 5 Years on Mars, NASA's Curiosity Rover Is Still Making Big Discoveries. Retrieved August 06, 2017, from https://www.space.com/37722-mars-rover-curiosity-five-years-anniversary.html

- Greicius, T. (2016, April 26). Cassini Explores a Methane Sea on Titan. Retrieved August 06, 2017, from https://www.nasa.gov/feature/jpl/cassini-explores-a-methane-sea-on-titan

- Ramsey, S. (2015, June 17). All Systems Go for NASA's Mission to Jupiter Moon Europa. Retrieved August 06, 2017, from https://www.nasa.gov/press-release/all-systems-go-for-nasas-mission-to-jupiter-moon-europa

- Wall, M. (2011, August 22). Meet the Solar System's Dwarf Planets. Retrieved August 06, 2017, from https://www.space.com/12692-dwarf-planets-solar-system-tour.html

- Dean, J. (2015, November 11). "Dwarf planets" on Revolvy.com. Retrieved August 06, 2017, from http://broom02.revolvy.com/topic/Dwarf%20planets&item_type=topic

- Cook up a Comet. (n.d.). Retrieved August 06, 2017, from http://clearinghouse.starnetlibraries.org/index.php?id_product=63&controller=product

- Cook, N. (Director). (2006). *Bye, Bye Planet Pluto* [Motion picture on DVD]. United Kingdom: BBC.

- Documentary – Killer Asteroids. (n.d.). Retrieved August 06, 2017, from https://youtu.be/rAJ2HZJlbLc

- Hamilton, D. (n.d.). Astronomy Workshop - Solar System Collisions. Retrieved August 06, 2017, from http://janus.astro.umd.edu/astro/impact/

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

STANDARDS: ***This refers to solar system dynamics only.***

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

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.

4.0	**Students will be able to:**

	• Predict the period (year) of a planet using Kepler's Laws • Decide whether the planets obey Kepler's Laws of Ellipses • Take a position on whether the solar nebula hypothesis explains the characteristics of the solar system
3.0	**Students will be able to:** • Compare and contrast the Copernican and Keplerian models of the solar system • Compare and contrast the reasons for retrograde motion offered by the Ptolemaic solar system and the Keplerian solar system • Trace the development of the heliocentric model • Trace the development of the solar system based on the solar nebula hypothesis • Generalize the stages of planet formation
2.0	**Students will be able to:** • Define the following terms in relation to astronomy: orbit; ellipse; semimajor axis; perihelion; aphelion; Kepler's Laws of Planetary Motion; geocentric; heliocentric; retrograde motion; solar nebula hypothesis; accretion; planetesimal; terrestrial planet; Jovian planet • Identify the discoveries made by Copernicus, Tycho, Galileo, and Kepler • Distinguish between the geocentric and heliocentric models of the solar system • Describe retrograde motion • Identify Kepler's three laws of planetary motion • Describe the characteristics of the solar system • Identify the terrestrial and Jovian planets
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: ***This refers to solar system characteristics only.*** **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.**	
4.0	**Students will be able to:** • Offer evidence of the solar nebula hypothesis using planetary and planetoid characteristics and behavior • Research exoplanetary systems and compare them to our solar system in terms of organization, orbits, and the possibility of life • Defend the idea that the Voyager mission to the outer planets was NASA's crowning achievement • Take a position on the inclusion/exclusion of Pluto as a planet
3.0	**Students will be able to:** • Classify a solar system object as a terrestrial planet, Jovian planet, or planetoid based on its description • Compare and contrast the terrestrial and Jovian planets • Compare and contrast asteroids and comets • Cite evidence for Pluto to not be a planet • Design a model solar system capable of supporting life using an online simulation • Analyze the motion of the Galilean satellites

2.0	**Students will be able to:** • **Define the following terms in relation to astronomy: terrestrial planets; Jovian planets; ice dwarfs; asteroids; comet; Kuiper Belt; asteroid belt; meteor; meteorite; meteor shower; Oort Cloud** • **Describe the characteristics of the planets and their satellites** • **Identify the major satellite of Jupiter, Saturn, Uranus, and Neptune** • **Visualize the effects of asteroid/comet/meteor impacts** • **Identify the major regions of the solar system**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
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English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
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	• Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
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Interdisciplinary Connections

Indicators:
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- 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.
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- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
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- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:

The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:

Asking questions and defining problems

Using Mathematics and Computational Thinking

Analyzing and Interpreting Data

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

Cross-Cutting Connections:

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

Cause and Effect

Connections to Nature of Science:

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

Unit Title: The Sun and Stellar Evolution
Unit Description: This unit will examine the formation, structure, properties and processes of stars, including the sun. The unit begins with a discussion of the structure and characteristics of the sun. The effects of solar magnetism on the earth will be discussed. The fusion process will examined. The life cycle of low and high mass stars will be covered in detail and their remnants will also be examined. This unit will also focus heavily on mathematical applications relating to stars and students will be expected to calculate such properties as temperature, luminosity, and life expectancy. Students will also construct and analyze an H-R diagram.
Unit Duration: 4 - 5 weeks
Desired Results
Standard(s): **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.** **HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements.**
Indicators: **HS-ESS1.A: The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.** **HS-ESS1.A: 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.A: 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-PS3.D: Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.** **HS-PS4.B: 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.**

Understandings:	Essential Questions:
Students will understand that… • The sun is an average star with an average lifespan. • The sun converts matter into energy by a process known as nuclear fusion. • The sun is currently converting hydrogen into helium, but will eventually convert helium into carbon, swelling into a red giant when it does so. • The sun will end its life about 5 billion years in the future and become a white dwarf star. • Magnetic activity on the sun can have negative effects on earth.	1. What makes up the interior of a star? 2. What makes up the atmosphere of a star? 3. What produces the magnetism of the sun? 4. How is the magnetism of the sun manifested? 5. What are sunspots? 6. What is the sunspot cycle and how does it affect the earth? 7. What is nuclear fusion? 8. How does the sun convert hydrogen into helium? 9. What are other products of the proton-proton chain reaction? 10. Why is the sun losing mass?

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- Spectroscopy is an important tool to identify the composition of stars and nebulae.
- Mass is the most important property of a star and determines the star's brightness and lifespan.
- High mass stars have much shorter life spans the low mass stars.
- The HR Diagram is a useful tool to graphically determine the evolutionary stage of a star.
- Stars are classified based on their temperature.
- Low mass stars end their lives as white dwarfs and planetary nebulae; high mass stars will end their lives violently as supernova.
- Stellar remnants of high mass stars also include neutron stars, pulsars, and black holes.

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11. What will happen to the sun when it has converted all its hydrogen?
12. Describe the life cycle of a low mass star.
13. How is the life cycle of a high mass star different from a low mass star?
14. What happens to stars at the end of their life cycle?
15. How does the mass of a star determine its life cycle?
16. What other characteristics of stars can ben determined by their mass?
17. What is spectroscopy? How is it used?
18. Describe the set up of the HR diagram.
19. For what is the HR Diagram used?
20. What are the common spectral classes?
21. What happens to stars at the end of their life cycles?

</td>
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<tr>
<th colspan="2">Assessment Evidence</th>
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Performance Tasks:

- Diagram the interior and atmosphere of a star.
- Calculate the energy produced during a fusion reaction.
- Graph the sunspot cycle and predict the next solar maxima.
- Create a model of a supernova – neutron star – black hole
- Create an HR Diagram and use it to determine stellar properties.

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Other Evidence:

- Quizzes
  - The Sun
  - Stellar Evolution
  - Stellar Remnants
- Lab Work
  - Sunspots
  - Vernier Lab – Light Brightness and Distance
  - Black Holes
- Independent Work
  - Teacher Made Review Sheets
  - Online Readings as listed with guided questions
  - Computer Activities
    - Sunspot Tracking
    - Stellar Evolution Web Quest
    - Spectroscopy
  - Analysis/Problem Solving/Models
    - Fusion Problems
    - HR Diagram Analysis
- Tests
  - One test at end of unit

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</table>

Benchmarks:

Unit Test

Learning Plan

Learning Activities:

Lesson One – The Sun (5 - 7 days)
Content – Sun Structure; Solar Fusion; The Solar Cycle
Reading – https://www.nasa.gov/feature/goddard/2017/two-weeks-in-the-life-of-a-sunspot
Activity – Lab – Sunspots; Sunspot Tracking; Fusion Problems; Video – The Universe: Magnetic Storm

Lesson Two – Stellar Evolution (4 - 6 days)
Content – Low Mass Stars; High Mass Stars; Stellar Remnants
Reading – http://astronomy.swin.edu.au/cosmos/S/Stellar+Evolution
Activity – Stellar Evolution Web Quest; Black Hole Lab

Lesson Three – Stellar Properties (4 - 6 days)
Content – The HR Diagram; Spectroscopy; Spectral Classes
Reading - http://www.skyandtelescope.com/astronomy-resources/the-spectral-types-of-stars/
Activity – Vernier Lab – Light Brightness and Distance; HR Diagram; Spectroscopy Computer Simulation Activity

Resources:

- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- Garner, R. (2017, August 04). Two Weeks in the Life of a Sunspot. Retrieved August 07, 2017, from https://www.nasa.gov/feature/goddard/2017/two-weeks-in-the-life-of-a-sunspot

- Motion picture on DVD – The Universe: Magnetic Storm. (n.d.). Retrieved August 07, 2017, from https://youtu.be/PKtPBi4zGN8

- Stellar Evolution | COSMOS. (n.d.). Retrieved August 07, 2017, from http://astronomy.swin.edu.au/cosmos/S/Stellar Evolution

- MacRobert, Alan | August 1, 2006, (2017, May 04). Spectral Types Important in Characterizing Stars. Retrieved August 07, 2017, from http://www.skyandtelescope.com/astronomy-resources/the-spectral-types-of-stars/

- Star Spectra Gizmo : Lesson Info : ExploreLearning. (n.d.). Retrieved August 07, 2017, from https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&resourceID=558

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: **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.**	
4.0	**Students will be able to:** • **Write and analyze a nuclear fusion reaction, determining the energy produced by the reaction** • **Predict the solar maxima (year) based on the solar cycle**
3.0	**Students will be able to:** • **Trace the migration of a photon from its production in the solar core to its arrival at Earth** • **Calculate the energy produced during the proton-proton chain reaction** • **Graph the sun spot cycle and analyze trends in the cycle** • **Compare and contrast sunspots, solar flares, and prominences** • **Determine the rate of solar rotation based on sunspot migration** • **Distinguish between the major types of solar fusion reactions**
2.0	**Students will be able to:** • **Define the following terms in relation to astronomy: core; convective zone; radiative zone; photosphere; chromosphere; corona; granulation; spicule; sunspot; prominence; solar flare; solar wind; coronal mass ejection; solar cycle; fusion; proton-proton chain reaction; triple alpha cycle; CNO process; neutrino; protium; deuterium; photon** • **Diagram the structure of the sun's interior and atmosphere** • **Identify manifestations of solar magnetic activity** • **Describe the effect of solar magnetism on the Earth**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
STANDARDS: **HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements.**	
4.0	**Students will be able to:** • **Create and analyze an HR Diagram to determine the life cycle of a star** • **Determine the relationship between apparent magnitude and distance** • **Classify stellar stages based on the nucleosynthesis reaction the star is undergoing**
3.0	**Students will be able to:** • **Compare and contrast the life cycle of low and high mass stars** • **Trace the development of a star from difuse nebula to stellar remnant** • **Create a principle to describe the relationship between stellar mass and other stellar properties (luminosity, life cycle, temperature, spectral class)** • **Categorize the various stellar remnants**

	• **Deduce the composition of a star/stellar remnant based on its spectra**
2.0	**Students will be able to:** • **Define the following terms in relation to astronomy: low mass star; high mass star; supermassive star; diffuse nebula; protostar; main sequence star; red giant; white dwarf; planetary nebula; supernova; neutron star; black hole; type II supernova; pulsar; HR Diagram; red dwarf; luminosity; spectral class; spectroscopy; magnitude; absolute magnitude; inverse square law** • **Match the stellar remnant to the type of star that produced it.** • **Identify the various types of spectral classes.** • **Describe the use of spectroscopy by astronomers**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, Mastering Meteorology) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered

	• Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
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Indicators:
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- 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.
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- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:

The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: The Deep Sky and Cosmology	
Unit Description: This final unit will focus on deep sky objects – star clusters, nebulae, and galaxies – as well as cosmology (the Big Bang). It will begin with a discussion of the structure of the Milky Way and other galaxies. Students will have the opportunity to participate in an on-line galaxy classification research activity, known as the Galaxy Zoo. In this activity, students will classify galaxy images as part of a cooperative NASA research program. The future of the Milky Way, active galaxies, and galaxy collisions will also be discussed. Students will then be given a simplified overview of the Big Bang theory, its evidence and what it signifies. Finally, students will engage in a collaborative project to explain the importance of NASA satellite research.	
Unit Duration: 3-4 weeks	
Desired Results	
Standard(s): **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.** **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-ETS1-3: 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.**	
Indicators: **HS-ESS1.A: 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-ETS1.A: Criteria and constraints also include satisfy ing any requirements set by society, such as taking issues of risk 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.** **HS-ETS1.B: When ev aluating 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.**	
Understandings: *Students will understand that…* • The sun is just one star among billions within the Milky Way galaxy. • There are three basic types of galaxies – spiral, elliptical, and irregular. • Spiral galaxies are defined by their flat disc and central bulge; they mostly contain stars like our sun. • Elliptical galaxies are "featureless" and contain mostly population II stars. • Irregular galaxies have no defined shape and contain many star forming regions.	**Essential Questions:** 1. How many stars are there in the Milky Way galaxy? 2. What is the shape of the Milky Way galaxy? 3. What are the three basic types of galaxies? 4. What are the characteristics of each type of galaxy? 5. How do galaxies change and evolve? 6. What are "active" galaxies? What causes their activity? 7. What does the Doppler Effect show about the motion of distant galaxies? 8. What does the motion of distant galaxies indicate about the expansion of the universe?

• Supermassive black holes form the cores of many galaxies. • Quasars are distant galaxies with active cores. • The Doppler Effect shows that distant galaxies are all moving away from the Milky Way. • Edwin Hubble used the motion of these galaxies to determine the expansion rate of the universe. • The expansion rate of the universe shows that at one time, 13 billion years ago, all matter in the universe was contained in a single point. • The Big Bang Theory explains how all matter was created from a massive explosion of space-time. • The Cosmic Background microwave radiation shows the distribution of energy shortly after the Big Bang. • NASA satellites (Earth-observing and non-Earth observing) are key to understanding how the Earth, sun and solar system operate.	9. What is the Big Bang Theory? 10. What evidence supports the Big Bang Theory? 11. How did the Big Bang create the matter we see in the universe today? 12. How do satellites (probes) study the universe? 13. How does data obtained from satellites improve life on Earth?
Assessment Evidence	

Performance Tasks:
• Diagram the various types of galaxies.
• Graph the motion of galaxies and use that information to extrapolate the expansion rate of the universe.
• Develop a presentation to highlight a current NASA satellite
	Other Evidence:
	• Quizzes
	  ○ Galaxies
	  ○ The Big Bang
	• Lab Work
	  ○ The Doppler Effect on Galaxies
	  ○ Determining the Hubble Constant
	  ○ Dark Matter
	• Independent Work
	  ○ Teacher Made Review Sheets
	  ○ Online Readings as listed with guided questions
	  ○ Analysis/Problem Solving/Models
	    ▪ Galaxies Identification Activity
	• Tests
	  ○ One test at end of unit
	• Project
	  ○ Satellite Funding Competition

Benchmarks:

Final Exam at the end of this unit

Learning Plan

Learning Activities:

Lesson One – Galaxies (4 - 6 days)
Content – The Milky Way; Types of Galaxies; Active Galaxies
Reading – http://www.astro.cornell.edu/academics/courses/astro201/galaxies/types.htm
Activity – Galaxy Identification Activity

Lesson Two – The Big Bang (5 - 7 days)
Content – Hubble's Law; Universal Expansion; Cosmic Background; History of the Universe
Reading – https://cosmictimes.gsfc.nasa.gov/online_edition/1929Cosmic/expanding.html; https://cosmictimes.gsfc.nasa.gov/online_edition/1965Cosmic/murmur.html; https://cosmictimes.gsfc.nasa.gov/online_edition/1993Cosmic/baby.html ; https://cosmictimes.gsfc.nasa.gov/online_edition/2006Cosmic/darkside.html
Activity – Lab – The Doppler Effect in Galaxies; Lab – Determining the Hubble Constant; Lab – Dark Matter; Video – NOVA: Back to the Beginning

Project – Satellite Funding Competition

Student teams wil select a current NASA satellite (Earth-observing or non-Earth Observing) and will research the mission, including costs, equipment, discoveries, and human benefit. Students will prepare a brochure and presentation to request continued funding from the Senate Budgetary Committee. This project highlights many areas of study from the entire year.

Resources:

- Butz, S. D. (2007). *Lab Manual to Accompany Science of Earth Systems* (2nd ed.). Clifton Park, NY: Thompson Delmar Learning.
- Mcnally, E. (2000, April). Types and Classification of Galaxies. Retrieved August 08, 2017, from http://www.astro.cornell.edu/academics/courses/astro201/galaxies/types.htm
- Galaxy Classification and Evolution. (n.d.). Retrieved August 8, 2017, from http://images.pcmac.org/SiSFiles/Schools/MO/JenningsSchool/JenningsSrHigh/Uploads-/Forms/Galaxy_Classification.pdf
- Cosmic Times Lesson Plans. (n.d.). Retrieved August 08, 2017, from https://cosmictimes.gsfc.nasa.gov/
- Degrasse-Tyson, N. (Writer). (2014, December 27). *NOVA: Back to the Beginning* [Video file]. Retrieved August 8, 2017, from https://youtu.be/621maypRngs

<table>
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(Level 2.0 reflects a minimal level of proficiency)</th></tr>
<tr><td colspan="2">STANDARDS:
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.</td></tr>
<tr><td>4.0</td><td>Students will be able to:
• Develop an argument for/against the use of Hubble’s Galaxy “Tuning Fork” Diagram as a tool for galaxy classification
• Test the idea that “dark matter” exists</td></tr>
<tr><td>3.0</td><td>Students will be able to:
• Trace the evolution of the universe from the Big Bang to the formation of galaxies
• Classify galaxies as spiral, elliptical, or irregular based on a visual inspection
• Compare and contrast the basic types of galaxies
• Develop a model to show the inflationary stage of the universe
• Experimentally determine the Hubble Constant</td></tr>
<tr><td>2.0</td><td>Students will be able to:
• Define the following terms in relation to astronomy: galaxy; spiral galaxy; elliptical galaxy; irregular galaxy; quasar; active galaxy; star cluster; population I star; population II star; expansionary universe; Hubble constant; Big Bang Theory; steady state model; Doppler Effect; dark matter; dark energy; cosmic background radiation; inflation
• Describe the features of the Milky Way galaxy
• Describe the appearance of each of the three galaxy types
• Summarize the evidence for the Big Bang</td></tr>
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• Develop a presentation to take a position on the benefits to humanity of a current NASA satellite</td></tr>
<tr><td>3.0</td><td>Students will be able to:
• Research the accomplishments of a selected NASA mission
• Assess the benefits associated with the selected NASA mission
• Critique other NASA missions to determine why the selected mission is superior</td></tr>
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• Identify a current NASA mission</td></tr>
</table>

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