CARLSTADT-EAST RUTHERFORD REGIONAL HIGH SCHOOL DISTRICT
SCIENCE DEPARTMENT
PHYSICS

Physics Curriculum Guide

Pacing Guide **Physics is a full year course that meets on a rotating basis for three (3) 55-minute blocks and one (1) 40-minute block for every five (5) day cycle.**	**Unit 1:** Force and Motion – 8 weeks **Unit 2:** Fundamental Forces – 4 weeks **Unit 3:** Kepler's Laws – 3 weeks **Unit 4:** Energy – 6 weeks **Unit 5:** Physics of the Geosphere – 3 weeks **Unit 6:** Wave Properties – 6 weeks **Unit 7:** Electromagnetic Radiation – 5 weeks **Unit 8:** Electricity and Magnetism – 5 weeks

Interdisciplinary Connections	Math HSN.Q.A.3: 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.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. ELA RST.9-10.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). RST.9-10.6. Determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. RST.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. RST.9-10.10. By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence. A. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. B. Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns. WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

	D. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically. WHST.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
21st Century Life and Careers:	9.2.12.C.1 Review career goals and determine steps necessary for attainment. 9.2.12.C.3 Identify transferable career skills and design alternate career plans.
Technology Standards	8.2.12.B.2 Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product. 8.2.12.B.4 Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants. 8.2.12.B.5 Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review. 8.2.12.C.4 Explain and identify interdependent systems and their functions.
NJSLS Career Ready Practices – These practices are demonstrated throughout the curriculum	CRP2. Apply appropriate academic and technical skills. CRP4. Communicate clearly and effectively and with reason. CRP5. Consider the environmental, social and economic impacts of decisions. CRP6. Demonstrate creativity and innovation. CRP7. Employ valid and reliable research strategies. CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP10. Plan education and career paths aligned to personal goals. CRP11. Use technology to enhance productivity. CRP12. Work productively in teams while using cultural global competence.

Differentiation/Accommodations/Modifications

Gifted and Talented	English Language Learners	Students with Disabilities	Students at Risk of School Failure
Extension Activities • Conduct research and provide presentation of mathematical topics. • Design surveys to generate and analyze data to be used in discussion. • Use of higher level questioning techniques. • Provide assessments at a higher level of thinking.	**Modifications for Homework/Assignments** • Modified assignments. • Extended time for assignment completion as needed. • Use graphing calculator. • Highlight formulas.	*(appropriate accommodations, instructional adaptations, and/or modifications as determined by the IEP or 504 team)* **Modifications for Classroom** • Ask students to restate information, directions, and assignments. • Repetition and practice. • Model skills / techniques to be mastered. • Extended time to complete class work. • Provide copy of class notes. • Preferential seating to be mutually determined by the student and teacher. • Students may request books online, on tape/CD, as available and appropriate. • Assign peer helper in the class setting. • Provide regular parent / school communication • Provide oral reminders and check student work during independent work time. • Assist student with long and short term planning of assignments	**Modifications for Classroom** • Ask students to restate information, directions, and assignments. • Repetition and practice. • Model skills / techniques to be mastered. • Extended time to complete class work. • Provide copy of class notes. • Preferential seating to be mutually determined by the student and teacher. • Students may request books online, on tape/CD, as available and appropriate. • Assign peer helper in the class setting. • Provide oral reminders and check student work during independent work time. • Assist student with long and short term planning of assignments • Provide regular parent / school communication. • Assign peer helper in the class setting. • Provide oral reminders and check student work during independent work time.

		Modifications for Homework • Extended time to complete assignments. • Student requires more complex assignments to be broken up and explained in smaller units, with work to be submitted in phases. • Provide the student with clearly stated (written) expectations and grading criteria for assignments. **Modifications for Assessments** • Extended time on classroom tests and quizzes. • Student may take / complete tests in an alternate setting as needed. • Restate, reread, and clarify directions/questions. • Distribute study guide for classroom tests. • Establish procedures for accommodations / modifications for assessments.	• Assist student with long and short term planning of assignments **Modifications for Homework** • Extended time to complete assignments. • Student requires more complex assignments to be broken up and explained in smaller units, with work to be submitted in phases. • Provide the student with clearly stated (written) expectations and grading criteria for assignments. **Modification for Assessments** • Extended time on classroom tests and quizzes. • Student may take / complete tests in an alternate setting as needed. • Restate, reread, and clarify directions/questions. • Distribute study guide for classroom tests. • Establish procedures for accommodations / modifications for assessments.

Unit 1: Force and Motion
Content: 1-Dimensional Motion, 2-Dimensional Motion, Vectors, Newton's Three Laws of Motion
Essential Questions: How can one explain and predict interactions between objects and within systems of objects?
Standards: HS-PS2-1, HS-PS2-2, HS-PS2-3, HS-ETS1-2, HS-ETS1-3
Time Frame: 8 weeks
Materials: Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET
Content: *As a result of this learning segment, students will know…* In this unit of study, students are expected to plan and conduct investigations, analyze data and using math to support claims, and apply scientific ideas to solve design problems students in order to develop an understanding of ideas related to why some objects keep moving and some objects fall to the ground. Students will also build an understanding of forces and Newton's second law. Finally, they will develop an understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are also able to apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and systems models are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems and to use these practices to demonstrate understanding of the core ideas.
Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…* Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Use mathematical representations of phenomena to describe explanations. Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engage: *Anticipatory Set* The following PHET Colorado online simulations can be used to introduce students to the topic of force and motion. http://phet.colorado.edu/en/simulation/forces-and-motion-basics http://phet.colorado.edu/en/simulation/forces-and-motion http://phet.colorado.edu/en/simulation/ramp-forces-and-motion

In this activity, students examine how different balls react when colliding with different surfaces. Also, they will have plenty of opportunity to learn how to calculate momentum and understand the principle of conservation of momentum. https://www.teachengineering.org/Activities/View/cub_energy_lesson03_activity3 Mythbusters Car Crash Force https://www.youtube.com/watch?v=r8E5dUnLmh4 Test Dummy Hitting Deployed Airbag http://www.gettyimages.com/detail/video/crash-test-dummy-hitting-deployed-airbag-berlin-germany-stock-footage/103250356
Exploration: *Student Inquiry* Applying Newton's Second Law Quantitatively In this lesson, students will solve a variety of problems with free body diagrams and Newton's Second Law. http://betterlesson.com/lesson/635014/applying-newton-s-second-law-quantitatively Combining Newton's Second Law and Kinematics In this lesson, students will solve a variety of problems with Newton's Second Law and the equations of motion. http://betterlesson.com/lesson/635295/combining-newton-s-second-law-and-kinematics Collision Lab : Introduction to One Dimension collisions https://phet.colorado.edu/en/contributions/view/3339 A Collisions Lab Students will be able to estimate the speed of an object by applying momentum conservation to collisions. http://betterlesson.com/lesson/636409/a-collision-lab Conservation of Momentum in Explosions The purpose of this experiment is to demonstrate conservation of momentum for two cars pushing away from each other. http://www-lhs.beth.k12.pa.us/faculty/Hoffman_M/Expt%2004%20Conservation%20of%20Momentum%20Explosions.pdf Demonstration Video https://www.youtube.com/watch?v=VZsTS1I5swI Crafting a Prototype to Protect An Egg During Freefall Students will utilize their understanding of momentum and collisions to create a prototype that prevents an egg from shattering upon impact. http://betterlesson.com/lesson/637585/crafting-a-prototype-to-protect-an-egg-during-freefall Hands-on Activity: Design a Bicycle Helmet In this activity, students are introduced to the biomechanical characteristics of helmets, and are challenged to incorporate them into designs for helmets used for various applications. By doing this, they come to understand the role of engineering associated with safety products. The use of bicycle helmets helps to protect the brain and neck in the event of a crash. To do this effectively, helmets must have some sort of crushable material to absorb the collision forces and a strap system to make sure the protection stays in place. The exact design of a helmet depends on the needs and specifications of the user. https://www.teachengineering.org/Activities/view/bicycle_helmet_activity
Explanation: *Concepts and Practices*

In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
PS2.A: Forces and Motion
Newton's second law accurately predicts changes in the motion of macroscopic objects.
Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.
ETS1.A: Defining and Delimiting an Engineering Problem
Criteria 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. (secondary)
ETS1.C: Optimizing the Design Solution
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary)

Elaboration: *Extension Activity*
An Introduction to Free Body Diagrams
Students use the vector nature of forces to draw free body diagrams.
http://betterlesson.com/lesson/630798/an-introduction-to-free-body-diagrams
Newton's Second Law in 1-D Motion
In this lesson, students will be able to identify Newton's Second Law and apply it to 1-dimensional motion.
http://betterlesson.com/lesson/631023/newton-s-second-law-in-1-d
Newton's Second Law in 2-D Motion
Students will be able to apply Newton's Second Law to 2-dimensional motions.
http://betterlesson.com/lesson/631088/newton-s-second-law-in-2-d
Related Activites:
http://www.physicsclassroom.com/NGSS-Corner/Force-and-Motion-DCIs-HS
http://www.ck12.org/ngss/high-school-physical-sciences/motion-and-stability:-forces-and-interactions

Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets	Chapter tests Projects / Presentations Section quizzes Final Exam Group activities

Unit 2: Fundamental Forces

Content: Newton's Law of Gravitation and Coulomb's Law

Essential Questions:
How can one explain and predict interactions between objects and within systems of objects?

Standards:
HS-PS2-4

Time Frame: 4 weeks

Materials:
Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET

Content: *As a result of this learning segment, students will know…*
In this unit of study, students plan and conduct investigations and apply scientific ideas to make sense of Newton's law of gravitation and Coulomb's Law. They apply these laws to describe and predict the gravitational and electrostatic forces between objects. The crosscutting concept of patterns is called out as an organizing concept for this disciplinary core idea. Students are expected to demonstrate proficiency in planning and conducting investigations and applying scientific ideas to demonstrate an understanding of core ideas.

Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…*
Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Engage: *Anticipatory Set*
The following PHET Colorado online simulations can be used to introduce Newton's Law of Gravitation and Coulomb's Law.
https://phet.colorado.edu/en/simulation/gravity-force-lab

Exploration: *Student Inquiry*
Gravitational Fields
http://www.physicsclassroom.com/NGSS-Corner/Activity-Descriptions/Gravitational-Fields-Description
Coulomb's Law Interactive
http://www.physicsclassroom.com/NGSS-Corner/Activity-Descriptions/Coulombs-Law
Electrostatic and Coulomb's Law: Lab
http://www.myips.org/cms/lib8/IN01906626/Centricity/Domain/8123/Coulombs%20Law%20E1.pdf

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):

PS2.B: Types of Interactions Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	
Elaboration: *Extension Activity* Related Activities http://www.ck12.org/ngss/high-school-physical-sciences/motion-and-stability:-forces-and-interactions/	
Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Group activities Section quizzes	Chapter tests Cumulative tests Projects / Presentations Midterm exam Final Exam

Unit 3: Kepler's Laws

Content: Kepler's Laws of Planetary Motion

Essential Questions:
How was it possible for NASA to intentionally fly into Comet Tempel 1?

Standards:
HS-ESS1-4

Time Frame: 3 weeks

Materials:
Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET

Content: *As a result of this learning segment, students will know…*
In this unit of study, students use mathematical and computational thinking to examine the processes governing the workings of the solar system and universe. The crosscutting concepts of scale, proportion, and quantity are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in using mathematical and computational thinking and to use this practice to demonstrate understanding of core ideas.

Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…*
Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Engage: *Anticipatory Set*
Video: Gravity Visualized
https://www.youtube.com/watch?v=MTY1Kje0yLg

Exploration: *Student Inquiry*
Gravity, Orbits and Kepler's Law
https://phet.colorado.edu/en/contributions/view/3874
Satellite Motion Lab
In this activity, students will experiment with satellite motion using an interactive simulation, gaining an understanding of Kepler's Laws of Satellite Motion and Newton's Synthesis.
https://phet.colorado.edu/en/contributions/view/3709
Going Full Circle on Gravity and Orbits- Day 1
In this lesson, students apply the circular motion equations to Newton's Universal Law of Gravity to derive circular orbit equations.
http://betterlesson.com/lesson/637802/going-full-circle-on-gravity-and-orbits-day-1
Going Full Circle on Gravity and Orbits- Day 2
In this lesson, students determine that satellites in a certain orbit are geostationary based on observations and what they know about orbital periods.
http://betterlesson.com/lesson/638515/going-full-circle-on-gravity-and-orbits-day-2

<table>
<tr><td colspan="2">Explanation: Concepts and Practices
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
ESS1.B: Earth and the Solar System
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.</td></tr>
<tr><td colspan="2">Elaboration: Extension Activity
Tides
Students will graph the tides in a region over a multi-day period to explain the factors which influence tides on the Earth and draw or identify the positions of the Earth, Moon, and Sun given specific tidal conditions.
http://betterlesson.com/lesson/641869/tides</td></tr>
<tr><td>Evaluation: Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)
Homework
Warm up exercises
Exit Tickets
Group activities
Section quizzes</td><td>Chapter tests
Cumulative tests
Projects / Presentations
Midterm exam
Final Exam</td></tr>
</table>

Unit 4: Energy

Content: Work, Energy, Power, and the Conservation of Energy

Essential Questions:
How is energy transferred and conserved?

Standards:
HS-PS3-2, HS-PS3-1, HS-PS3-3, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4

Time Frame: 6 weeks

Materials:
Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET

Content: *As a result of this learning segment, students will know…*
In this unit of study, students develop and use models, plan and carry out investigations, use computational thinking and design solutions as they make sense of the disciplinary core idea. The disciplinary core idea of Energy is broken down into subcore ideas: definitions of energy, conservation of energy and energy transfer, and the relationship between energy and forces. Energy is understood as a quantitative property of a system that depends on the motion and interactions of matter, and the total change of energy in any system is equal to the total energy transferred into and out of the system. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect, systems and systems models, energy and matter, and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations. Students are expected to demonstrate proficiency in developing and using models, planning and carry out investigations, using computational thinking and designing solutions, and they are expected to use these practices to demonstrate understanding of core ideas.

Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…*
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
Create a computational model or simulation of a phenomenon, designed device, process, or system.
Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Engage: *Anticipatory Set*
Video: Energy Lost When a Ball Bounces (Can be done as classroom demonstration)
https://www.youtube.com/watch?v=ZSOxVwTv58Q
Ballistic Pendulum Physics
https://www.youtube.com/watch?v=l87Dr2lJEOk
Roller Coaster Physics
https://www.youtube.com/watch?v=-dpBVtAbKJU
King Da Ka- Front Row

https://www.youtube.com/watch?v=HN8nv4tVFuA
Exploration: *Student Inquiry* Skate Park Energy Students learn the concepts of kinetic and potential energy as they explore a skateboard simulation. http://betterlesson.com/lesson/638233/skate-park-energy Venn Diagram of Kinetic and Potential Energies Students compare and contrast kinetic energy and potential energy by creating a Venn Diagram of the two types of energy.S http://betterlesson.com/lesson/638234/venn-diagram-of-kinetic-and-potential-energies Skate Park Energy Revisited Students determine how friction and the shape of the ramp impact the transformation of potential into kinetic energy. http://betterlesson.com/lesson/638235/skate-park-energy-revisited Simple Pendulum Lab https://phet.colorado.edu/en/contributions/view/3591 The Springy Pen Lab Students will be able to prove conservation of energy in a pen's spring. http://betterlesson.com/lesson/634088/the-springy-pen-lab The Conservation of Energy Pendulum The purpose of this experiment is to measure the potential energy and the kinetic energy of a mechanical system and to quantitatively compare the two forms of mechanical energy to determine if the total mechanical energy is conserved. http://www.austincc.edu/mmcgraw/Labs_1401/8c-Con%20of%20Energy-Pendulum-RGC-1-15-09.pdf Ramp and Review In this hands-on activity—rolling a ball down an incline and having it collide into a cup—the concepts of mechanical energy, work and power, momentum, and friction are all demonstrated. During the activity, students take measurements and use equations that describe these energy of motion concepts to calculate unknown variables and review the relationships between these concepts. https://www.teachengineering.org/Activities/view/cub_energy_lesson05_activity2 Roller Coaster Design: Day 1 Students design their own roller coasters, calculate potential energy and apply conservation of energy to calculate the velocities at key points of the ride. http://betterlesson.com/lesson/638238/roller-coaster-design-day-1 Roller Coaster Design: Day 2 Students design their own roller coasters and calculate important aspects of the ride like velocities, work and power of the motor, and braking force. http://betterlesson.com/lesson/639206/roller-coaster-design-day-2 Rube Goldberg Contraptions https://www.teachingchannel.org/videos/rube-goldberg-contraptions Introduction Video:

https://www.youtube.com/watch?v=ieQSiDnOhzY

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
PS3.A: Definitions of Energy
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
PS3.B: Conservation of Energy and Energy Transfer
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

The availability of energy limits what can occur in any system.
PS3.D: Energy in Chemical Processes
Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
ETS1.A: Defining and Delimiting an Engineering Problem
Criteria 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. (secondary)

Elaboration: *Extension Activity*
Swinging Pendulum
https://www.teachengineering.org/Activities/view/cub_energy_lesson03_activity2
Related Activites
http://www.ck12.org/ngss/high-school-physical-sciences/energy/
Energy and the Pogo Stick

Students learn about the conservation of energy with the inclusion of elastic potential energy. They use pogo sticks to experience the elastic potential energy and its conversion to gravitational potential energy. https://www.teachengineering.org/Activities/view/van_hybrid_design_activity3 Students design their own marble roller coaster. http://betterlesson.com/lesson/639604/marble-roller-coaster-lab
Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Group activities Section quizzes Chapter tests Cumulative tests Projects / Presentations Midterm exam Final Exam

Unit 5: Physics of the Geosphere

Content: Earth and Space Sciences

Essential Questions:
How much force and energy is needed to move a continent?

Standards:
HS-ESS2-1, HS-ESS2-3, HS-ESS1-5, HS-ESS2-2

Time Frame: 3 weeks

Materials:
Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET

Content: *As a result of this learning segment, students will know…*
In this unit of study, students construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space sciences involves making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. Students develop models and explanations for the ways that feedback among different Earth systems controls the appearance of the Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down land through weathering and erosion. Students demonstrate proficiency in developing and using models, constructing explanations, and engaging in argument from evidence. The crosscutting concepts of stability and change, energy and matter, and patterns are called out as organizing elements of this unit.

Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…*
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Engage: *Anticipatory Set*
This activity will have students analyze pieces of rationale for why the Earth is round and give them an introductory glimpse into the major zones of the Earth.
http://betterlesson.com/lesson/626681/introduction-to-the-earth
Students will take use their newfound knowledge of density to apply relative densities to the interior of the Earth and its associated layers.
http://betterlesson.com/lesson/626690/layers-of-the-earth-i
In these lessons, students will analyze pieces of rationale for why the Earth is round and discuss the differences between relative and absolute dating.
http://betterlesson.com/lesson/617979/introduction-to-the-rock-cycle
http://betterlesson.com/lesson/635124/introduction-to-relative-dating
In this lesson, students identify thermometers as the instruments used to measure temperatures, examine kinetic energy as a function of molecular movement, and then examine the differences between weather and climate.

http://betterlesson.com/lesson/636579/weather-temperature

Exploration: *Student Inquiry*
This lesson will introduce students to the phenomenon of earthquakes as the creation of seismic waves caused by friction along plate boundaries and faults.

http://betterlesson.com/lesson/626691/earthquakes-day-1-2
This simulation will have students explore how plates move on the surface of the earth by adjusting the temperature, composition, and thickness of plates.

https://phet.colorado.edu/en/simulation/legacy/plate-tectonics
In this lesson, students diagram where the world's earthquakes and volcanoes occur.
http://betterlesson.com/lesson/632020/earthquake-volcano-mapping
In this simulation, students will identify an unknown material by calculating its density and comparing to a table of known densities.
https://phet.colorado.edu/en/simulation/legacy/density
In this lesson, students explore the early atmosphere and how organisms contributed oxygen via photosynthesis.
http://betterlesson.com/lesson/635127/early-atmosphere-fossils
In this simulation, students will adjust mountain snowfall and temperature to see a glacier grow and shrink. Use scientific tools to measure thickness, velocity, and glacial budget.
https://phet.colorado.edu/en/simulation/legacy/glaciers
In this lesson, students will create a topographic map given a landscape formation.
http://betterlesson.com/lesson/639110/topographic-maps-lab
In this lesson, students will describe the effect of greenhouse gases on photons and temperature and will be able to explain why greenhouse gases affect temperature.

https://phet.colorado.edu/en/simulation/legacy/greenhouse

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
ESS1.C: The History of Planet Earth
Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

ESS2.A: Earth Materials and Systems
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur

primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. ESS2.B: Plate Tectonics and Large-Scale System Interactions Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary) ESS2.D: Weather and Climate 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. PS1.C: Nuclear Processes Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary) PS4.A: Wave Properties Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)	
Elaboration: *Extension Activity* This lesson introduces students to the phenomenon of earthquakes as the creation of seismic waves caused by friction along plate boundaries and faults. http://betterlesson.com/lesson/631663/earthquakes-day-2-2 In this lesson, students try to solve a unique challenge problem showing how an aircraft carrier can float in water. http://betterlesson.com/lesson/626688/density-the-earth In this lesson, students interpret and apply knowledge from maps of geologic bedrock and diagrams of geologic history pertaining to New York State. http://betterlesson.com/lesson/635128/interpreting-geologic-bedrock-in-new-york-state In this lesson, students mathematically calculate the gradient for topographic profiles in order to figure out the direction of stream movement. http://betterlesson.com/lesson/640535/topographic-maps-ii-stream-movement-gradient	
Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Section quizzes	Chapter tests Cumulative tests Projects / Presentations Final Exam Group activities

Unit 6: Wave Properties

Content: Waves

Essential Questions:
How are waves used to transfer energy and send and store information?

Standards:
HS-PS4-1

Time Frame: 6 weeks

Materials:
Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET

Content: *As a result of this learning segment, students will know…*
In this unit of study, students apply their understanding of how wave properties can be used to transfer information across long distances, store information, and investigate nature on many scales. The crosscutting concept of cause and effect is highlighted as an organizing concept for these disciplinary core ideas. Students are expected to demonstrate proficiency in using mathematical thinking, and to use this practice to demonstrate understanding of the core idea.

Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…*
Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Engage: *Anticipatory Set*
The following NYU and PHET Colorado online simulations can be used to introduce students to the topic of waves.
http://www.physics.nyu.edu/~ts2/Animation/waves.html#
https://phet.colorado.edu/en/simulation/wave-on-a-string
https://phet.colorado.edu/en/simulation/legacy/wave-interference

Exploration: *Student Inquiry*
In this lesson, students will explore the relationship between wavelength, period, and velocity of a wave.
http://betterlesson.com/lesson/636453/velocity-law-for-waves
In this lesson, students will explore the wave characteristics of light.
http://betterlesson.com/lesson/636454/the-nature-of-light-wave-properties

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
PS4.A: Wave Properties

The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
Elaboration: *Extension Activity* In this lesson, students will develop qualitative relationships for wave quantities. http://betterlesson.com/lesson/639694/wave-relationships In this lesson, students will quantitatively and qualitatively define the Doppler effect. http://betterlesson.com/lesson/640765/the-doppler-effect
Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Group activities Section quizzes Chapter tests Cumulative tests Projects / Presentations Midterm exam Final Exam

Unit 7: Electromagnetic Radiation
Content: Electromagnetism
Essential Questions: Why has digital technology replaced analog technology?
Standards: HS-PS4-3, HS-PS4-4, HS-ETS1-1, HS-PS4-5, HS-PS4-2, HS-ETS1-3
Time Frame: 5 weeks
Materials: Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET
Content: *As a result of this learning segment, students will know…* In this unit of study, students are able to apply their understanding of wave properties to make sense of how electromagnetic radiation can be used to transfer information across long distances, store information, and be used to investigate nature on many scales. Models of electromagnetic radiation as both a wave of changing electrical and magnetic fields or as particles are developed and used. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of systems and system models; stability and change; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts. Students are expected to demonstrate proficiency in asking questions, engaging in argument from evidence, and obtaining, evaluating, and communicating information, and they are expected to use these practices to demonstrate understanding of the core ideas.
Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…* Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). Analyze complex real-world problems by specifying criteria and constraints for successful solutions. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engage: *Anticipatory Set* In this lesson, students will be able to identify the wave phenomena. http://betterlesson.com/lesson/639703/wave-lab-stations-day-1 In this lesson, students will explore what materials block the microwaves that are emitted or are received by their mobile phones. http://betterlesson.com/lesson/645259/what-materials-block-your-phone-s-signal

In this lesson, students will be able to manipulate information to write wave equations, sketch waves, and describe key wave characteristics.
http://betterlesson.com/lesson/636198/wave-properties
In this lesson, students use double-length slinkys and slow motion video to determine how waves interact with each other and with a fixed barrier.
http://betterlesson.com/lesson/640692/slinky-rules
In this lesson, students observe the application of standing waves resulting from wave interference.
http://betterlesson.com/lesson/640740/standing-waves-demonstrations
In this lesson, students will be able to explain how sound is created and define key terms such as resonance, intensity, and beats.
http://betterlesson.com/lesson/640632/splashing-around-with-sound

Exploration: *Student Inquiry*
The following activity can be used to have students interactively learn about wave phenomena.
http://betterlesson.com/lesson/639704/wave-lab-stations-day-2
This simulation will have students discuss wave properties using common vocabulary and predict the behavior of waves through varying medium.
https://phet.colorado.edu/en/simulation/wave-on-a-string
The following activities interactively teach students about radiation and radio waves.
http://betterlesson.com/lesson/636197/what-is-radiation
https://phet.colorado.edu/en/simulation/legacy/radio-waves
In this lesson, students construct an explanation for how standing waves form when an incident wave interferes with a reflected wave.
http://betterlesson.com/lesson/640738/standing-waves
In this simulation, students make waves with a dripping faucet, audio speaker, or laser and add a second source or a pair of slits to create interference.
https://phet.colorado.edu/en/simulation/legacy/wave-interference
In these simulations, students will design ways to determine the speed, frequency, period and wavelength of a sound wave model.
https://phet.colorado.edu/en/simulation/legacy/sound
In this simulation, students will learn how to make waves of all different shapes and compare different mathematical expressions for waves.
https://phet.colorado.edu/en/simulation/legacy/fourier

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
PS3.D: Energy in Chemical Processes
Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary)
PS4.A: Wave Properties

[From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. PS4.B: Electromagnetic Radiation Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. PS4.C: Information Technologies and Instrumentation Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	
Elaboration: *Extension Activity* In these lessons, students will engage in a variety of explorations of electromagnetic phenomenon. http://betterlesson.com/lesson/636830/electromagnetic-investigations-day-1 http://betterlesson.com/lesson/636213/electromagnetic-investigations-day-2 http://betterlesson.com/lesson/637306/electromagnetic-investigations-day-3 This lesson will have students identify and distinguish between new forms of radiation that are the result of nuclear reactions. http://betterlesson.com/lesson/638128/radioactivity-part-one In this lesson, students experiment with different colors of lights to understand how they combine to create new colors. http://betterlesson.com/lesson/645256/mixing-colors-with-light In this lesson, students design their own musical instrument and apply the concept of standing waves to determine its frequencies. http://betterlesson.com/lesson/641215/design-your-own-instrument	
Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Group activities Section quizzes	Chapter tests Cumulative tests Projects / Presentations Midterm exam Final Exam

Unit 8: Electricity and Magnetism
Content: Electric Forces, Electric Fields, Magnetic Forces, and Magnetic Fields
Essential Questions: How can one explain and predict the interactions between objects and within a system of objects?
Standards: HS-PS2-5, HS-PS3-5
Time Frame: 5 weeks
Materials: Whiteboard with markers, Computers with internet access, Lab equipment, Vernier probes with Vernier software, Physics: Principles & Problems [Glencoe, 9th edition], Physics [Cutnell and Johnson, 5th edition], WebAssign, YouTube, BetterLesson, PhET
Content: *As a result of this learning segment, students will know…* In this unit of study, students' understanding of how forces at a distance can be explained by fields, why some materials are attracted to each other while other are not, how magnets or electric currents cause magnetic fields, and how charges or changing magnetic fields cause electric fields. The crosscutting concept of cause and effect is called out as an organizing concept. Students are expected to demonstrate proficiency in planning and conducting investigations and developing and using models.
Student Learning Objective (SLO): *As a result of this learning segment, students will be able to…* Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
Engage: *Anticipatory Set* In this lesson, students research how electric power is produced on a large scale and what natural resources are used to produce that power. http://betterlesson.com/lesson/645166/generating-interest-in-generators In this lesson, students will draw upon previous knowledge of charges to build a strong connection between the ideas of charges and electric forces. http://betterlesson.com/lesson/629444/introduction-to-electrostatics
Exploration: *Student Inquiry* In this simulation, students will explore the interactions between a compass and bar magnet. https://phet.colorado.edu/en/simulation/legacy/magnets-and-electromagnets In this lesson, students use a simulator to determine the mathematical relationships between voltage, current and resistance for a simple circuit. http://betterlesson.com/lesson/644735/ohm-on-the-range In this simulation, students will build circuits with resistors, light bulbs, batteries, and switches. https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-dc In this simulation, students will observe how Ohm's law relates to a simple circuit by adjusting the voltage and resistance.

https://phet.colorado.edu/en/simulation/ohms-law

Explanation: *Concepts and Practices*
In these lessons
Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices.
Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):
PS2.B: Types of Interactions
Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
PS3.A: Definitions of Energy
"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)
PS3.C: Relationship Between Energy and Forces
When two objects interacting through a field change relative position, the energy stored in the field is changed.

Elaboration: *Extension Activity*
In these lessons, students will engage in a variety of explorations of electromagnetic phenomenon.
http://betterlesson.com/lesson/636830/electromagnetic-investigations-day-1
http://betterlesson.com/lesson/636213/electromagnetic-investigations-day-2
http://betterlesson.com/lesson/637306/electromagnetic-investigations-day-3
http://betterlesson.com/lesson/638023/electromagnetic-investigations-day-4
In this lesson, students will determine the rules that govern voltages and currents of series and parallel circuits.
http://betterlesson.com/lesson/644765/parallel-and-series-circuits
In this lesson, students will explore simple circuits and differentiate between series and parallel combinations.
http://betterlesson.com/lesson/641962/constructing-circuits
In this lesson, students will be able to calculate the equivalent resistance and apply Ohm's Law to series, parallel, and complex resistor circuits.
http://betterlesson.com/lesson/641968/series-parallel-complex-resistor-combinations

Evaluation: *Assessment (The above Essential Questions will be assessed with the following formative and summative measures:)* Homework Warm up exercises Exit Tickets Section quizzes	Chapter tests Cumulative tests Projects / Presentations Group activities Final Exam