NEW MILFORD PUBLIC SCHOOLS

New Milford, Connecticut

Honors Physics

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New Milford Board of Education

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BOE Approved November 2019

New Milford's Mission Statement

The mission of the New Milford Public Schools, a collaborative partnership of students, educators, family and community, is to prepare each and every student to compete and excel in an ever-changing world, embrace challenges with vigor, respect and appreciate the worth of every human being, and contribute to society by providing effective instruction and dynamic curriculum, offering a wide range of valuable experiences, and inspiring students to pursue their dreams and aspirations.

Physics Honors

Grade 12

This course covers the topics of motion, forces, energy, sound, light, electricity, and magnetism. A significant portion of the work is in the laboratory, requiring laboratory reports to be written. A good mathematical background is required, including an understanding of Algebra principles and some geometry and trigonometry. Several projects are required, one of which will include a paper. At the honors level, this course is more rigorous, and moves at a faster pace. Additional homework is required.

Physics Honors
Pacing Guide

	Number of weeks
Unit 1 Motion and Forces	12
Unit 2: Conservation of Energy and Momentum	8
Unit 3: Electricity and Magnetism	10
Unit 4: Waves, Sound, Light	6
Unit 5: Heat and Thermodynamics	4

<table>
<tr><th colspan="3">Unit 1: Forces and Motion - Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">ESTABLISHED GOALS
HS-PS2-1 - Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration
HS-PS2-4 - Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects
CCSS.ELA-LITERACY.RST11-12.3 - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing other technical tasks; analyze the specific results based on explanations in the text</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning by…
SEP-1 Asking Questions and Defining Problems
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking
SEP-8 Obtaining, Evaluating, and Communicating Information</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS (DCIs)
Students will understand that…
PS2.A: Forces and Motion
-Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
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. (HS-PS2-4)</td><td>ESSENTIAL QUESTIONS
Students will keep considering…
How can one explain and predict interactions between objects and within systems of objects?
Why do objects keep moving and what causes objects’ motions to change?
Why are some materials attracted to each other while others are not?
How would modern life be different if certain physical quantities were not conserved?</td></tr>
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<tr>
<td rowspan="3">● CCSS.ELA-LITERACY.RST11-12.4 - 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 related to grades 11-12 texts and topics
● CCSS.MATH.CONTENT.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.
● CCSS.MATH.CONTENT.HSN.VM.A.1- Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
● CCSS.MATH.CONTENT.HSN.VM.A.3-Solve problems involving velocity and other quantities that can be represented by vectors.</td>
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<tr>
<td colspan="2">Acquisition</td>
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<tr>
<td>Students will know…

● Objects continue to move at a constant speed or stay at rest when no net force is applied
● Objects change their motion when a net force is applied.
● Freely falling bodies undergo constant acceleration.
● The horizontal and vertical components of motion of a projectile are independent of one another.
● Projectiles follow parabolic trajectories.
● Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
● Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2-4)
● Free body diagrams are used to model forces acting on a single object.
● Forces occur in equal and opposite pairs.</td>
<td>Students will be skilled at…

● Interpret motion plots for both vertical and horizontal motion of a projectile
● Determine the final state of a projectile's kinematic quantities if given the initial state
● Describe how the Newton (the unit) is defined
● Distinguish between mass and force
● Calculate the weight of an object if given its mass (or mass if given weight)
● Determine the magnitude and direction of gravitational forces between two objects
● Determine the magnitude and direction of frictional forces
● Categorize a force as a contact force or a field force acting at a distance
● Categorize a force as a gravitational force, normal force, force of tension, drag force, force of friction
● Differentiate when a problem can be modeled with an object alone or when a system of objects has to be created
● Apply constant acceleration kinematics equation in order to solve various one-dimensional and two-dimensional motion problems.
● Calculate resultant vectors using algebraic methods.
● Evaluate forces as acting within a system or on the system as a whole</td>
</tr>
</table>

		● Draw free free body diagrams in order to determine the magnitude and direction of the net force acting on an object or system in order to apply Newton's 2nd law ● Apply Newton's 1st and 3rd laws to determine qualitative and quantitative answers to different physical configurations ● Evaluate a quantitative answer as being within or outside a reasonable expectation ● Draw a Newton's 3rd law diagram showing all force pairs ● Create experiments that reveal the relationship between acceleration and force as well as the relationship between acceleration and the mass of a system

Unit 1: Forces and Motion - Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
A, M, T	Lab report	PERFORMANCE TASK(S): *Students will show that they really understand evidence of the acceleration due to gravity and Newton's second law.* **Goal:** To determine the acceleration of gravity and evaluate the accuracy of different measurement techniques. **Role:** You are a test engineer. **Audience:** Your supervisor @ United Technologies, Pratt and Whitney, Middletown,CT **Situation:** Your supervisor wants you to evaluate different lab equipment by measuring one of the most well-known physical constants. **Product or Performance:** You will need to determine the acceleration of gravity using a variety of methods and graph your results. You will then need to evaluate the accuracy of those methods by comparing your work with the accepted value for g. **Standards for Success**: Rubric.
OTHER EVIDENCE:	*Students will show they have achieved Stage 1 goals by…*	
A,M,T	Lab Reports	
M,T	Questioning of students	

A,T	Practice problems	
A,M	Summative Assessments	

Unit 1: Forces and Motion - Stage 3 – Learning Plan		
Code	***Pre-Assessment*** *KWL Charts* *Brainstorming at the beginning of a unit* *mind / concept mapping* *Formal pre-assessment to match the post assessment - optional*	
Code	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring ● Quizzes on content ● Lab report write ups ● Questions on activities ● Questioning for comprehension ● End of unit assessment/ post-test
M	Graph Matching – Vernier Lab, Honors version: Use a motion detector to duplicate graphs of motion. **H, E, E2**	
M/T	Walk, Jog, Run Lab, Honors version: Graph and analyze data from students walking, jogging, and running down the hallway. **H, R, E2**	
A/M	LAB: Modern Galileo and Free Fall – Prove It!, Honors version: Determine gravitational acceleration with a variety of labs. **H, E2**	
M	End of Unit test: Summative assessment. **E2**	
M/T	Shoot for your Grade Lab, Honors version: Demonstrate mastery of projectile motion. **H, R, E2**	
M	Inertia Smorgasbord wkst/Activity: Experiment with and explain inertia phenomena. **H, E, T**	
M/T	Newton's 2nd Law Lab (Vernier Lab): Analyze and interpret graphs of forces to derive mechanics equation. **H, E, T**	
A/M	The “Mu” of Your shoe, Honors version: Analyze data and calculate coefficient of friction. **H, E2, T**	
A/M	3 subunit exams and occasional quizzes: Summative assessments. **E2**	
M	WebAssign - online homework platform, requires application and synthesis of physics concepts	

Unit 2: Conservation of Energy and Momentum - Stage 1 Desired Results		
ESTABLISHED GOALS ● **HS-PS2-2** - Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system ● **HS-PS2-3** - Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision ● **HS-PS3-1** - Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known ● **HS-PS3-2** - Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy	***Transfer*** *Students will be able to independently use their learning by…* SEP-2 Developing and Using Models SEP-3 Planning and Carrying Out Investigations SEP-4 Analyzing and Interpreting Data SEP-5 Using Mathematics and Computational Thinking SEP-6 Constructing Explanations and Designing Solutions SEP-8 Obtaining, Evaluating, and Communicating Information	
	Meaning	
	UNDERSTANDINGS (DCIs) *Students will understand that…* ● **PS2.A Forces and Motion** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) ● If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) ● **PS3.A: Definitions of Energy** ● Energy is a quantitative property of a system that depends on the motion and interactions of matter and	ESSENTIAL QUESTIONS *Students will keep considering…* ● How can one explain and predict interactions between objects and within systems of objects? ● Why do objects keep moving and what causes objects' motions to change? ● What is done to make collisions safer and why do these methods work? ● What is energy and how is it transferred and conserved? ● How would modern life be different if certain physical quantities were not conserved? ● How can applied forces affect the energy of an object or system? ● How is energy used to improve the quality of our lives?

associated with the motions of particles (objects) and energy associated with the relative position of particles (objects) ● **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 ● **CCSS.ELA-LITERACY.RST11-12.3** - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing other technical tasks; analyze the specific results based on explanations in the text ● **CCSS.ELA-LITERACY.RST11-12.4** - 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	radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2) ● At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3) ● These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)	

related to grades 11-12 texts and topics	• **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. (HS-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) • 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. (HS-PS3-1) • The availability of energy limits what can occur in any system. (HS-PS3-1)	
	Acquisition	
	Students will know… • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)	*Students will be skilled at…* • Calculate the amount of work performed in a process and indicate if it is positive or negative

	• Work is a transfer of energy between systems. • The total momentum and energy of a system is conserved. • An unbalanced force on an object produces a change in its momentum. • Energy is a quantitative property of a system that depends on the motion and interactions of matter within that system. (HS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (HS-PS3-3) • In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). (HS-PS3-2) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems or converted to less useful forms (e.g thermal energy). (HS-PS3-4) • Kinetic energy of a system depends on mass and speed. • The availability of energy limits what can occur in any system. (HS-PS3-1) • Power is the rate at which energy is transformed.	• Determine the gravitational potential energy of an object based on its position in a gravitational field. • Determine the kinetic energy of an object or system. • Apply energy conservation in order to solve problems for various quantities (e.g. speed, height of object) • Calculate the momentum of an object or system. • Classify collisions between objects or systems as perfectly inelastic or elastic. • Determine if the kinetic energy of a system is conserved during a collision. • Apply the impulse-momentum theorem in order to solve problems. • Apply the work-energy theorem in order to solve problems. • Evaluate collision scenarios and offer ways to decrease or increase impact force depending for each situation.

Unit 2: Conservation of Energy and Momentum - Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
M/T	Schoolwide rubric	PERFORMANCE TASK(S): **Goal:** The challenge is to design and create a small lightweight container to mail a single loose Pringle(R). **Role:** You are a packaging engineer. **Audience:** Your boss, the head of research and design ak Kellogg's Foods. **Situation:** Your boss wants to cut costs on shipping while preserving the integrity of the product. **Product or Performance:** You will need to design a package that doesn't use traditional packing materials such that ' the package has the lowest possible weight, is small, but still meets minimum USPS requirements. **Standards for Success**: Your work will be judged by the size and weight of the package and condition of the Pringle(R) after it has been delivered according to a rubric.
Other Evidence		
A,M,T	Lab Reports	
M,T	Questioning of students	

A,T	Practice problems	
A,M	Summative Assessments	

Unit 2: Conservation of Energy and Momentum - Stage 3 – Learning Plan

	Pre-Assessment *KWL Charts* *Brainstorming at the beginning of a unit* *mind / concept mapping* *Formal pre-assessment to match the post assessment - optional*	
Code	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring ● Quizzes on content ● Lab report write ups ● Questions on activities ● Questioning for comprehension ● End of unit assessment/ post-test
A/T	Vernier Lab: Energy of a Tossed Ball: Analyze and calculate transfers of energy **W, E2**	
M/T	"Stairmaster" Power Lab, Honors version: Calculate human work and power outputs **H, E, R, E2, T**	
M/T	Vernier Lab: Conservation of Momentum: Predict and explain conservation of momentum **W, E, R, E, O**	
A/M	2 subunit exams and occasional quizzes: Summative assessment **E2**	

Unit 3: Electric and Magnetic Phenomena - Stage 1 Desired Results

<table>
<tr><td rowspan="4">ESTABLISHED GOALS
HS-PS2-5 - Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current
HS-PS2-4 - Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects
HS-PS3-3 - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy
HS-PS3-5 - Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning by…
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS (DCIs)
Students will understand that…
PS2.B Types of Interactions
Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5)
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)
PS3.A Definitions of Energy
"Electrical energy" may mean energy stored in a battery or energy</td><td>ESSENTIAL QUESTIONS
Students will keep considering…
How can one explain and predict interactions between objects and within systems of objects?
Why do objects keep moving and what causes objects' motions to change?
Why are some materials attracted to each other while others are not?
What is energy and how is it transferred and conserved?
How would modern life be different if certain physical quantities were not conserved?
How can applied forces affect the energy of an object or system?
How is energy used to improve the quality of our lives?</td></tr>
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<tr>
<td rowspan="4">changes in energy of the objects due to the interaction
HS-ETS1-2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering
HS-ETS1-3 - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts
CCSS.ELA-LITERACY.RST11-12.3 - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing other technical tasks; analyze the specific results based on explanations in the text
CCSS.ELA-LITERACY.RST11-12.4 - Determine the meaning of symbols, key terms, and other</td>
<td>transmitted by electric currents. (secondary to HS-PS2-5)
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. (HS-PS3-5)
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. (HS-PS2-4)</td>
<td></td>
</tr>
<tr>
<td colspan="2">Acquisition</td>
</tr>
<tr>
<td>Students will know…</td>
<td>Students will be skilled at…</td>
</tr>
<tr>
<td>Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5)
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)
“Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5)
When two objects interacting through a field change relative position, the</td>
<td>Compare and contrast electrostatic and gravitational forces
Determine the magnitude and direction of electrostatic and gravitational forces between two objects.
Explain how charged particles are sources of electric fields and are subject to the forces of electric fields caused by other charges
Apply Ohm’s law to in order to calculate the voltage drop, the current flow and the resistance of a component within a circuit.
Predict and explain why the flow of electric current is affected and distributed through parallel and series circuits</td>
</tr>
</table>

domain-specific words and phrases as they are used in a specific scientific or technical context related to grades 11-12 texts and topics ● **CCSS.ELA-LITERACY.RST11-12.7** - Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem ● **CCSS.ELA-LITERACY.RST11-12.9** - Synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible	energy stored in the field is changed. (HS-PS3-5) ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	● Predict and explain why voltage drops across each component in parallel and series circuits. ● Explain why any resistive element dissipates energy by heating the resistor. ● Determine the equivalent resistance of series circuits and parallel circuits. ● Calculate the power in any resistive circuit element ● Explain that moving charge is the source of all magnetic fields and moving charge may be subject to forces of existing magnetic fields. ● Explain the conditions when changing magnetic fields can create electric current flow in conductors.

Unit 3: Electric and Magnetic Phenomena - Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
M, T	Modified school wide rubric	PERFORMANCE TASK(S): *Students will show that they really understand evidence of how much electric power is used by common household devices* **Background/Purpose**: Every appliance in your home uses electricity when it is "on". Some appliances turn on automatically, some you turn on yourself. When the appliance is turned on, electric current flows through its wiring and supplies the energy needed by the device. Each appliance has its own power rating which can be used to calculate how much electricity is being used by that appliance. Also, your home has an electric meter which measures the amount of energy, in kilowatt hours (kWh), your family uses in a given amount of time. The electric company charges you for the number of kilowatt hours you've used based on the cost of each kilowatt hour and the delivery charges associated with getting that electricity to your home. **Goal**: You will collect appliance usage data from your home over a total of 24 hours (can be all at once, or broken into smaller periods of time based on your schedule) and use that data to calculate how much you are contributing to your household's electric bill each month. You will then reflect on your electricity consumption and come up with some strategies or steps you can take to reduce the amount of electricity you consume. **Project Requirements**: *The project will contain the following components*: *Initial Data Collection* - use the electricity usage journal sheet to record the appliances you use on a regular basis, each appliance's electricity usage (Wattage), the estimated amount of time each appliance was running and the number of Watt-hours the electric company would bill you for each appliance. *Data Analysis* - you will then calculate the cost of your energy usage (both energy AND delivery charges) *Reflection* - once you've determined how much your electricity cost, reflect on the following questions: -Of the appliances or devices you used, were any left plugged in? Do these devices still use electricity when plugged in but are turned "off"? Did you account for this "phantom energy" in your analysis? - Do you think you could reduce the amount of electricity you use? How? What changes could you make to save money on your electric bill?

		-Did anything surprise you in your analysis? Do you use a lot more electricity than you thought? Do you use less than you thought?
OTHER EVIDENCE:		
A,M,T	Lab Reports	
M,T	Questioning of students	
A,T	Practice problems	
A,M	Summative Assessments	

Unit 3: Electric and Magnetic Phenomena - Stage 3 – Learning Plan		
	Pre-Assessment *KWL Charts* *Brainstorming at the beginning of a unit* *mind / concept mapping* *Formal pre-assessment to match the post assessment - optional*	
Code	Summary of Key Learning Events and Instruction. Student success at transfer meaning and acquisition depends on…	Progress Monitoring ● Quizzes on content ● Lab report write-ups ● Questions on activities ● Questioning for comprehension ● End of unit assessment/ post-test
M	Electrophorus Activity (Charging by Induction), Honors version: Explain methods of charging**. H**	
A	PhET Electrostatics Demos/ Explorations: Explain methods of charging and electron motion**.T**	
M/T	Van de Graff Generator Demos: Explain movement of electrons.H,T	
A/M/T	Batteries and Bulbs Intro. to Circuits Activity: Create and analyze simple circuits **R,E2,T**	
M/T	Ohm's Law Lab: Derive and explain Ohm's law. **E,T**	
A	Magnet Mania: Discovery lab. **W,H,R,E2,T**	
A/T	Magnetic Fields visualized, Honors version: Discovery lab. **H,R,T,O**	
M/T	Building a Motor and Speaker Lab, Honors version: Design and create a solution.**W,H,E,E2,T,O**	
A/M	Chapter Exams: Summative assessment. **E2**	

Unit 4 - Waves, Sound, Light - Stage 1 Desired Results

ESTABLISHED GOALS

- **HS-PS4-1** - Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media
- **HS-PS4-2** - Evaluate questions about the advantages of using a digital transmission and storage of information
- **HS-PS4-3** - Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other
- **HS-PS4-4** - Evaluate the validity and reliability of claims in published

Transfer

Students will be able to independently use their learning to…

SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information.

Meaning

UNDERSTANDINGS (DCIs)

Students will understand that…

- **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. (HS-PS4-1)
- 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. (HS-PS4-3).
- **PS4.B Electromagnetic Radiation**

ESSENTIAL QUESTIONS

Students will keep considering…

- How can one explain and predict interactions between objects and within systems of objects?
- Why do objects keep moving and what causes objects' motions to change?
- What is energy and how is it transferred and conserved?
- How can applied forces affect the energy of an object or system?
- How are waves used to transfer energy and send and store information?
- How is energy used to improve the quality of our lives?
- How are waves used to study otherwise inaccessible objects?

materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter ● **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 ● **CCSS.ELA-LITERACY.RST11-12.1** 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. ● **CCSS.ELA-LITERACY.RST11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them	● Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) ● When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)	
	Acquisition	
	Students will know… ● The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) ● Waves can add or cancel one another as they cross, depending on their	*Students will be skilled at…* ● Classify waves as either transverse or longitudinal. ● Contrast the type of particle vibrations that creates a transverse wave with the type of particle vibrations that create a longitudinal wave

in simpler but still accurate terms. • **CCSS.ELA-LITERACY.RST11-12.3** - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing other technical tasks; analyze the specific results based on explanations in the text • **CCSS.ELA-LITERACY.RST11-12.4** - 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 related to grades 11-12 texts and topics • **CCSS.ELA-LITERACY.RST11-12.7** - Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem • **CCSS.ELA-LITERACY.RST11-12.9** - Synthesize information from a range of sources into a coherent understanding of a	relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (HS-PS4-3) • Electromagnetic radiation is a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) • Waves have characteristic behaviors such as interference, diffraction, refraction and polarization. • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. (HS-PS4-3) • When longer wavelength electromagnetic radiation (e.g. light) is absorbed in matter, it is generally converted into thermal energy (heat). (HS-PS4-4) • Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)	• Identify the aspects of a wave within a graph: such as amplitude, wavelength and period • Calculate wavelengths, frequencies and speeds of waves. • Apply the principle of superposition to overlapping waves to determine points of constructive and destructive interference. • Describe how the speed of sound changes when traveling through solids, liquids or gases. • Predict the angle of reflection of light ray when it reflects off a surface • Predict the direction a light ray will be bent as it passes from one medium to another • Identify the type of interaction between light and matter as reflection, refraction or diffraction if given examples. • Identify or give examples when light needs to be modeled as a wave and when it needs to be modeled as a particle • Explain and give examples of how human society uses waves to communicate • Explain why digital wave signals are the dominate mode of communication • Analyze, synthesize, and evaluate information from credible sources in order to form an evidence based opinion on a current real-world issue involving electromagnetic radiation. • Calculate the frequency, speed, and length of a harmonic for a string, open pipe or closed pipe.

process, phenomenon, or concept, resolving conflicting information when possible ● **CCSS.MATH.CONTENT. 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. ● **CCSS.MATH.CONTENT. HSN.Q.A.2**-Define appropriate quantities for the purpose of descriptive modeling. ● **CCSS.MATH.CONTENT. HSA.SSE.A.1**-Interpret expressions that represent a quantity in terms of its context. ● **CCSS.MATH.CONTENT. HSA.CED.A.4** -Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations		● Correlate an observed harmonic series with a standing wave model of a string, open pipe or closed pipe system.

Unit 4 - Waves, Sound, Light - Stage 2 – Evidence		
Code	Evaluative Criteria	Assessment Evidence

M, T	Schoolwide rubric	PERFORMANCE TASK(S): **Goal:** Evaluate the validity and reliability of claims in published materials of the effects of electromagnetic radiation on materials (e.g. Effectiveness of Sunscreen, Are UV Nail Lamps Safe?). **Role:** You are a personal health advocate. **Audience:** Readers of a prominent personal health magazine **Situation:** The magazine editor would like to publish your argumentative article about the safety of one of the suggested current topics. **Product or Performance:** Write an argumentative essay in support of a position of one of the given issues using evidence from at least two opposing views. **Standards for Success:** Rubric.

		OTHER EVIDENCE:
A,M,T	Lab Reports	
M,T	Questioning of students	
A,T	Practice problems	
A,M	Summative Assessments	

Unit 4 - Waves, Sound, Light - Stage 3 – Learning Plan

	Pre-Assessment *KWL Charts* *Brainstorming at the beginning of a unit* *mind / concept mapping* *Formal pre-assessment to match the post assessment - optional*

Code	Summary of Key Learning Events and Instruction. Student success at transfer meaning and acquisition depends on…	Progress Monitoring • Quizzes on content • Lab report write-ups • Questions on activities • Questioning for comprehension • End of unit assessment/ post-test
M	Speed of Sound in Air Investigation, Honors version: Calculate the speed of sound experimentally and analyze data **H, R, E2**	
M	Speed of Marshmallow lab, Honors version: Analyze data and calculate the speed of light **H, T, O**	
A/T	Measuring the angle of incidence and reflection lab: Explore the interactions of light rays at boundaries **H, R, E2**	
A/M	2 subunit tests and occasional quizzes: Summative assessment **E2**	

<table>
<tr><th colspan="3">Unit 5 Heat and Thermodynamics Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">ESTABLISHED GOALS
● HS-PS3-1 - Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known
● HS-PS3-2 - Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects)
● HS-PS3-4 - Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of a different temperature are combined within a closed system results in a more uniform</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
● 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. (HS-PS3-1),(HS-PS3-2)
● At the macroscopic scale, energy manifests itself in multiple ways, such</td><td>ESSENTIAL QUESTIONS
Students will keep considering…
● How can one explain and predict interactions between objects and within systems of objects?
● Why do objects keep moving and what causes objects' motions to change?
● What is energy and how is it transferred and conserved?
● How would modern life be different if certain physical quantities were not conserved?
● How can applied forces affect the energy of an object or system?
● How is energy used to improve the quality of our lives?</td></tr>
</table>

energy distribution among the components in the system ● **HS-ETS1-2** - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering ● **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts ● **CCSS.ELA-LITERACY.RST11-12.3** - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing other technical tasks; analyze the specific results based on explanations in the text ● **CCSS.ELA-LITERACY.RST11-12.4** - Determine the meaning of symbols, key terms, and other	as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3) ● These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) ● **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. (HS-PS3-1) ● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)	

domain-specific words and phrases as they are used in a specific scientific or technical context related to grades 11-12 texts and topics ● **CCSS.ELA-LITERACY.RST11-12.7** - Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem ● **CCSS.ELA-LITERACY.RST11-12.9** - Synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible	● 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. (HS-PS3-1) ● The availability of energy limits what can occur in any system. (HS-PS3-1) ● Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)	
	Acquisition	
	Students will know… ● Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)	*Students will be skilled at…* ● Describe how the kinetic molecular theory connects atomic motion to macroscopic physical quantities such as work, temperature, pressure, quantity and volume

	• Temperature of an ideal gas is a measure of the average kinetic energy of its molecules. • Naturally, all gases, liquids and solids expand as they are heated. • Heat is energy that is transferred from one system to another by means of conduction, convection, or radiation. • Specific heat is a material property that describes the energy required to raise an object's temperature or the amount of energy released by that object as it cools. • During phase transitions, heat is absorbed or released without changes in temperature (latent heat).	• Calculate the specific heat of an unknown material by using the specific heat of water as a control. • Be able to identify the modes of heat transfer as conduction, convection, or radiation if given specific examples (ex: roasting a marshmallow on the coals of a fire) • Give examples of when thermal expansion has to be accounted for in engineering designs • Explain the ramifications of solid state heat flow rates as a function of temperature during cooking • List and explain the major ways society transfers energy into forms we use and the resulting human and global ramifications • Explain how air conditioners and heat pumps work to force heat flow in the desired direction while reconciling with the laws of thermodynamics that state heat flows from the hotter to the cooler, energy is conserved and entropy is increased in a closed system

Unit 5 Heat and Thermodynamics Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, M	Lab report	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* Heat Transfer lab Role: Engineering student Audience: Engineering Supervisor, University of New Haven, West Haven, CT Format: Formal lab report Task: Explain how thermal energy can be transferred between parts of a system which are in thermal equilibrium with each other.
A,M,T	Lab Reports	
M,T	Questioning of students	
A,T	Practice problems	
A,M	Summative Assessments	

Unit 5 Heat and Thermodynamics Stage 3 – Learning Plan		
	Pre-Assessment *KWL Charts* *Brainstorming at the beginning of a unit* *mind / concept mapping* *Formal pre-assessment to match the post assessment - optional*	
Code	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring ● Quizzes on content ● Lab report write-ups ● Questions on activities ● Questioning for comprehension ● End of unit assessment/ post-test
M, T	Heat Transfer lab, Honors version - explore experimentally how thermal energy moves between systems **H, E, R, E2, O**	
M, T	Energy Skate Park Friction, Honors version - Examine the effects of thermal energy in the context of the laws of thermodynamics **W, H, R, T**	
A, M	Summative assessment **E2**	