Course Title:	Content Area:	Grade Level:	Credit (if applicable)
UConn ECE Physics 1201Q/1202Q	Science	12	1.0 BPS 1201Q: 4.0 UConn 1202Q: 4.0 UConn

Course Description:

Through quantitative and qualitative analysis, students will gain a deeper understanding of matter, forces, and the interaction between them. Major units of study include: Kinematics, Newton's Laws, Conservation Laws, Rotation, SHM/Waves, and Gravitation for Physics 1201Q; electrostatics, electric circuits, magnetostatics, electrodynamics, geometric and physical optics, atomic and nuclear physics, and the particle nature of light for Physics 1202Q. Through cooperative learning and lab experiences, students will improve communication and critical thinking skills.

Aligned Core Resources:	Connection to the *BPS Vision of the Graduate*
College Physics (Serway 2019)	CONTENT MASTERY • Develop and draw from a baseline understanding of knowledge in academic disciplines from our Bristol curriculum. CRITICAL THINKING AND PROBLEM SOLVING • Collect, assess and analyze relevant information • Reason effectively. Use systems thinking. • Make sound judgments and decisions. Identify, define and solve authentic problems and essential questions. • Reflect critically on learning experience, processes and solutions. • Transfer knowledge to other situations.

Additional Course Information: ***Knowledge/Skill Dependent courses/prerequisites***	**Link to *Completed Equity Audit***
	Equity Audit=ECE Physics

Standard Matrix

AP Science Practices	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10
Practice 1: Modeling-The student can use representations and models to communicate scientific phenomena and solve scientific problems.										
1.1 The student can create representations and models of natural or man-made systems in the domain.	X	X	X	X	X	X	X	X	X	X
1.2 The student can describe representations and models of natural or man-made phenomena and	X	X	X	X	X	X	X	X	X	X

systems in the domain.										
1.3 The student can refine representations and models of natural or man made phenomena and systems in the domain.	X	X	X	X	X	X	X	X	X	X
1.4 THe student can use representations and models to analyze or solve problems qualitatively and quantitatively.	X	X	X	X	X	X	X	X	X	X
1.5 The student can re-express key elements of natural phenomena across multiple representations in the domain.	X		X	X	X	X	X	X		X
Practice 2: Mathematical Routines-The student can use mathematics appropriately.										
2.1 The student can justify the selection of a mathematical routine to solve a problem.	X	X	X	X	X	X	X	X	X	X
2.2 The student can apply mathematical routines to quantities that describe natural phenomena.	X	X	X	X	X	X	X	X	X	X
Practice 3: Experimental Methods-The student can plan and implement data collection strategies in relation to a particular scientific question.										
3.1 The student can justify the selection of the kind of data needed to answer a particular science question.	X	X	X	X	X	X		X		X
3.2 The student can collect data to answer a particular scientific question.	X	X	X	X	X	X	X	X	X	X
3.3 The student can evaluate sources of data to answer a particular scientific question.	X	X	X	X	X	X	X	X	X	X
Practice 4: Data Analysis-The student can perform data analysis and evaluation of evidence										
4.1 The student can analyze data to identify patterns or relationships.	X	X	X	X	X	X	X	X	X	X
4.2 The student can refine observations and measurements based on data analysis.	X									
4.3 The student can evaluate evidence provided by data sets in relation to a particular scientific question.	X	X	X		X	X		X	X	X
Practice 5: Argumentation-The student can work with scientific explanations and theories.										

5.1 The student can articulate the reasons that scientific explanations and theories are refined or replaced.						X				X
5.2 The student can make claims and predictions about natural phenomena based on scientific theories and models.	X	X	X	X	X	X	X	X	X	X
Practice 6: Making Connections-The student is able to connect and relate knowledge across various scales, concepts and representations in and across topics.										
6.1 The student can connect phenomena and models across spatial and temporal scales.			X	X	X	X	X	X	X	X

Unit Links

[Kinematics (1201)]
[Newton's Laws (1201)]
[Conservation Laws (1201)]
[Rotation (1201)]
[Simple Harmonic Motion (1201)]
[Thermal Physics (1202)]
[Gravitation (1202)]
[Electricity and Magnetism (1202)]
[Electric Current and Circuits (1202)]
[Waves and Optics (1202)]
[Modern Physics (1202)]

Unit Title:	
Kinematics (1201)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.2, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How can the motion of objects be predicted and/or explained? • Can equations be used to answer questions regardless of the questions' specificity? • How can the idea of frames of reference allow two people to tell the truth yet have conflicting reports? • How can we use models to help us understand motion? • Why is the general rule for stopping your car "when you double your speed, you must give yourself four times as much distance to stop?"	Position, Displacement, and Distance: • Understanding the difference between position, displacement, and distance. • Recognizing that displacement is a vector quantity that includes both magnitude and direction. Speed and Velocity: • Defining speed as the magnitude of velocity. • Understanding velocity as a vector quantity with both magnitude and direction. Acceleration: • Defining acceleration as the rate of change of velocity. • Understanding that acceleration is a vector quantity with both magnitude and direction. Equations of Motion: • Applying kinematic equations to describe the motion of an object in one dimension. Projectile Motion: • Understanding the motion of projectiles launched at an angle to the horizontal. • Analyzing projectile motion using kinematic principles. Graphical Representations of Motion: • Interpreting and creating graphs representing position, velocity, and acceleration vs. time. • Understanding the relationships between slopes and areas under these graphs. Motion in Two Dimensions: • Applying kinematic principles to describe the motion of objects in two dimensions. • Recognizing the independence of motion in perpendicular directions. Relative Motion: • Analyzing motion from different reference frames. • Understanding how velocity and acceleration transform between reference frames. Instantaneous and Average Values: • Differentiating between instantaneous and average values of velocity and acceleration. • Recognizing that instantaneous values are determined at a specific instant, while average values are over a time interval.

	Uniform Circular Motion: • Understanding the kinematics of objects moving in a circle at a constant speed. • Recognizing the relationships between linear and angular kinematics.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut shared assessments	4 Weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Acceleration, average speed, constant, constant acceleration, displacement, dynamics, frame of reference, free-fall acceleration, instantaneous speed, instantaneous velocity, kinematics, magnitude, motion diagram, one-dimensional motion, order of magnitude, projectile motion, relative velocity, scalar, stationary, vector, vector quantity, velocity	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**
The CELP guidance is to* ***support the development of language**; access to course content expectations should not change as a result of MLL status.* An EL can conduct research and evaluate and communicate findings to answer questions or solve problems. **I can use the equations of motion to solve problems.** • Level 1: I can name the define the components of basic formulas like distance=speed×time with support. • Level 2: I can interpret and manipulate the equations of motion with guidance. • Level 3: I can analyze motion scenarios (word problems) and choose appropriate equations to solve problems	

independently. I can explain my problem-solving process and justify my choices of equations.

- Level 4: I can critique and refine problem-solving strategies based on verbal or written feedback.
- Level 5: I can synthesize information from multiple sources to solve real-world problems involving motion and explain my solutions effectively.

Lesson Sequence	**Learning Target**	**Success Criteria**
1 Equations of Kinematics and free fall	I can use the equations of motion to solve problems.	• I can identify given variables and make a plan to solve kinematics problems. • I can infer necessary or missing information, so I can solve a problem. This may include developing an algorithm. • I can develop/solve a series of equations to solve for all required variables. • I can recognize the limitations of the equation(s). • I can anticipate failures and persevere in learning to solve challenging problems in physics. • I can make and interpret motion graphs.
2 Vectors	I can appropriately manipulate vector quantities as required to solve problems.	• I can recognize situations when vector composition is required. • I can recognize when to resolve a vector into components.
3 Projectile motion	I can solve problems involving projectiles.	• I can recognize the independence of a projectile's horizontal and vertical motions. • I can appropriately apply vector techniques as needed. • I can appropriately apply the equations of kinematics as needed.

Unit Title:	
Newton’s Laws (1201)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2)	
Essential Question(s):	**Enduring Understanding(s):**
• What are Newton's Three Laws of Motion, and how do they provide a framework for understanding the fundamental principles governing the motion of objects? • How can free-body diagrams and force diagrams be used as visual tools to represent and analyze the forces acting on an object in equilibrium or in motion?	First Law (Law of Inertia): • Understanding Newton's First Law, which states that an object at rest will remain at rest, and an object in motion will remain in motion with a constant velocity unless acted upon by a net external force. • Recognizing the concept of inertia as an object's resistance to changes in its state of motion. Second Law: • Understanding Newton's Second Law, which states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. • Expressing the relationship as $F=ma$, where F is the net force, m is the mass and a is the acceleration. Third Law: • Understanding Newton's Third Law, which states that for every action, there is an equal and opposite reaction. • Recognizing that forces always occur in pairs, and the action and reaction forces act on different objects. Force Diagrams (Free-Body Diagrams): • Constructing force diagrams to represent the forces acting on an object. • Analyzing force diagrams to determine the net force and acceleration of an object. Applications of Newton's Laws: • Applying Newton's laws to analyze the motion of objects under the influence of various forces. • Solving problems involving forces, masses, and accelerations. Frictional Forces: • Understanding the role of frictional forces and differentiating between static and kinetic friction. • Analyzing situations involving friction and determining the net force. Tension Forces and Normal Forces: • Analyzing tension forces in strings and cables and normal forces in contact situations. • Recognizing how these forces contribute to the net force acting on an object. Applications to Circular Motion:

	• Applying Newton's laws to analyze circular motion, including centripetal and centrifugal forces. • Recognizing that a net force is required to maintain circular motion. Gravitational Forces: • Understanding the gravitational force acting between two objects with mass. • Applying Newton's law of universal gravitation. Applications to Equilibrium: • Analyzing situations in which objects are in equilibrium, with the net force and net torque equal to zero. • Understanding the conditions for static equilibrium.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut shared assessments	4 Weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Acceleration, coefficient of friction, contact forces, field forces, force, free-body diagram, friction, frictional force, gravitational force, inertia, mass, newton, Newton's second law, Newton's third law, normal force, object in equilibrium, static, tension, universal gravitational constant, weight	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**
The CELP guidance is to **support the development of language; access to course content expectations should*	

not change as a result of MLL status.

I can follow the procedure to solve problems involving forces.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

- Level 1: With prompting and support, follow simple step-by-step procedures to solve basic force-related problems. I can label and identify basic force-related terms and concepts.
- Level 2: With prompting and support, follow step-by-step procedures to solve force-related problems. I can record and summarize basic data and information related to force problems.
- Level 3: With guidance and support, follow procedures to solve force-related problems independently. I can gather information from word problems to understand and apply force concepts.
- Level 4: I can follow procedures to solve force-related problems both independently and collaboratively. Gather and synthesize information from multiple print and digital sources to solve force problems. I can integrate problem information into organized oral or written explanations and problem solutions.
- Level 5: I can analyze and integrate information providing thorough explanations and solutions to force-related problems. I can apply advanced problem-solving strategies to solve force-related problems in various contexts.

Lesson Sequence	Learning Target	Success Criteria
1	*I can recognize how Newton's Laws describe the possible effects of forces acting on a body.*	• I can recognize equilibrium conditions, • I can recognize non-equilibrium conditions. • I can identify action/reaction force pairs.
2	I can follow the procedure to solve problems involving forces.	• I can use appropriate expressions to calculate forces. • I can draw a free body diagram. • I can use free body diagrams to generate relevant Newton's second law equations.

Unit Title:	
Conservation Laws (1201)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• What are conservation laws, and how do they provide a foundation for understanding and predicting the behavior of physical systems? • How does the conservation of energy manifest in various physical processes, and what are the implications for understanding mechanical systems?	Conservation of Energy: • Understanding the principle that the total mechanical energy of an isolated system is conserved. • Recognizing the interconversion of kinetic energy and potential energy. Conservation of Linear Momentum: • Understanding the principle that the total linear momentum of an isolated system remains constant in the absence of external forces. • Applying the conservation of linear momentum to analyze collisions and explosions. Conservation of Angular Momentum: • Understanding the principle that the total angular momentum of an isolated system remains constant in the absence of external torques. • Recognizing how changes in moment of inertia or angular velocity affect angular momentum. Conservation of Charge: • Understanding the principle that the total electric charge in an isolated system is conserved. • Recognizing the conservation of charge in electrical circuits and interactions. Conservation of Mass (in Non-Nuclear Reactions): • Recognizing the principle that the total mass of an isolated system is conserved in non-nuclear reactions. Conservation of Energy-Mass Equivalence ($E=mc^2$): • Understanding the relationship between mass and energy in the context of nuclear reactions. • Recognizing the equivalence of mass and energy as described by Einstein's equation $E=mc^2$. Conservation of Linear Momentum in Two Dimensions: • Applying the conservation of linear momentum separately in each dimension (horizontal and vertical) in collisions and other interactions. Conservation of Mechanical Energy in a System with Non-Conservative Forces: • Recognizing situations where non-conservative forces (such as friction) are present and understanding how mechanical energy is not conserved.

<table>
<tr><td></td><td>Conservation of Energy in Simple Harmonic Motion:
Understanding how mechanical energy is conserved in ideal conditions during simple harmonic motion.
Conservation of Energy in Circular Motion:
Applying the conservation of energy principle to analyze circular motion.</td></tr>
<tr><th>Demonstration of Learning:</th><th>Pacing for Unit</th></tr>
<tr><td>University of Connecticut released assessments</td><td>4 Weeks</td></tr>
<tr><th>Unit-specific Vocabulary:</th><th>Aligned Unit Materials, Resources, and Technology (beyond core resources):</th></tr>
<tr><td>Average force, average power, collision, conservative force, conservation, conservation of energy, conservation of momentum, electrical transmission, elastic collision, electromagnetic radiation, energy, foot-pound, gravitational work, heat, impulse, impulse-momentum theorem, inelastic collision, instantaneous power, joule, kinetic energy, linear momentum, mechanical energy, mechanical waves, momentum, newton, newton-meter, nonconservative force, potential energy, power, recoil, system, Watt, Work, work-energy theorem</td><td></td></tr>
<tr><th colspan="2">Differentiation through Universal Design for Learning</th></tr>
<tr><th>UDL Indicator</th><th>Teacher Actions:</th></tr>
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</table>

I can use the work/energy theorem to solve problems.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

- Level 1: With prompting and support, I can understand basic concepts related to the work/energy theorem and use them to solve simple problems with some help.
- Level 2: I can record and summarize data related to energy and work, with some guidance provided.
- Level 3: I can gather information about a word problem and paraphrase key information in written or oral explanations, possibly including illustrations or diagrams.
- Level 4: I can synthesize information to explore various applications of the work/energy theorem.
- Level 5: I can independently, analyze and solve complex word problems related to the work/energy theorem.

Lesson Sequence	Learning Target	Success Criteria
1 Work and Energy	I can recognize the relationship between work and energy.	• I can use the work/energy theorem to solve problems.
2 Power	I can recognize that time is often a practical matter when doing work.	• I can identify power as the rate at which energy is converted from one form to another.
3 Conservation of Energy	I can recognize problem types which can be solved using conservation of energy.	• I can solve problems when mechanical energy is conserved (no friction) • I can recognize situations (involving friction) where mechanical energy is lost as heat to the surroundings
4 Impulse and Momentum	I can recognize the relationship between impulse/momentum.	• I can use impulse /momentum to solve appropriate problems.
5 Conservation of Momentum	I can recognize problem types which can be solved using conservation of momentum.	• I can apply conservation of momentum for problems involving recoil and collisions. • I can identify collision types in terms of kinetic energy concerns.

Unit Title:	
Rotation (1201)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How does rotational motion differ from linear motion, and what key quantities and concepts characterize rotational dynamics? • What is the significance of understanding the moment of inertia in rotational motion, and how does it affect an object's response to torques? • In what ways can we apply Newton's laws to analyze and predict the rotational motion of objects and systems? • How does torque contribute to rotational motion, and what factors influence the torque experienced by an object?	Angular Displacement, Velocity, and Acceleration: • Defining angular displacement as the change in angle or position. • Understanding angular velocity as the rate of change of angular displacement. • Recognizing angular acceleration as the rate of change of angular velocity. Rotational Kinematics: • Applying kinematic equations to describe the motion of rotating objects. • Understanding the relationship between linear and angular kinematics. Moment of Inertia: • Defining moment of inertia as a measure of an object's resistance to changes in rotational motion. • Recognizing how the distribution of mass affects the moment of inertia. Torque and Newton's Second Law for Rotation: • Defining torque as the rotational analog of force, causing angular acceleration. • Understanding Newton's second law for rotation: $\tau = I\alpha$, where is torque, *I* is moment of inertia, and α is angular acceleration. Rotational Energy and Work: • Understanding rotational kinetic energy and its relationship with linear kinetic energy. • Recognizing the work-energy principle in rotational motion. Conservation of Angular Momentum: • Understanding the conservation of angular momentum for isolated systems. • Recognizing how changes in moment of inertia or angular velocity affect angular momentum. Rolling Motion: • Analyzing the motion of objects that roll without slipping. • Understanding the relationship between translational and rotational motion. Rotational Equilibrium: • Understanding conditions for rotational equilibrium, where the net torque is zero. • Recognizing the relationship between torque and

	lever arms. Angular Impulse and Collision: • Understanding angular impulse as the product of torque and time. • Recognizing the conservation of angular momentum in collisions. Precession and Gyroscopic Motion: • Understanding the precession of rotating objects. • Analyzing gyroscopic motion and its stability.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Angular acceleration, angular displacement, angular position, angular velocity, average angular velocity, center of mass, centripetal acceleration, constant of universal gravitation, conservation of angular momentum, instantaneous angular acceleration, instantaneous angular speed, instantaneous angular velocity, Kepler's laws, moment of inertia, radial acceleration, rotational equilibrium, rotational second law of motion, Radian, tangential acceleration, tangential velocity, tension, torque, uniform circular motion	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**

The CELP guidance is to **support the development of language; access to course content expectations should not change as a result of MLL status.*

I can apply Newton's second law for equilibrium in both the linear and rotational form to build a sufficient number of equations to solve the problem.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

- Level 1: I can understand the basic principles of Newton's second law for equilibrium in simple situations with some help. I can identify and label forces involved in a problem.
- Level 2: I can explain Newton's second law for equilibrium and identify forces in a problem with some support. I can start to write basic equations based on linear and rotational forms of the law.
- Level 3: I can evaluate the forces involved in a word problem, write equations in both linear and rotational forms, and start solving problems with guidance.
- Level 4: I can effectively build equations in both linear and rotational forms, integrate them to solve complex problems, and cite sources properly.
- Level 5: I can generate a sufficient number of equations in both linear and rotational forms, integrate them seamlessly, and present my findings clearly and accurately, citing sources appropriately.

Lesson Sequence	Learning Target	Success Criteria
1 Circular Motion	I can recognize the effect of a force that is applied perpendicular to the motion.	• I can understand how a particle can accelerate while traveling at constant speed. • I can recognize uniform circular motion as an application of Newton's Laws. • I can solve circular motion problems.
2 Rotational kinematic	I can recognize the need for angular variables to describe rotational motion.	• I can recognize the kinematics equations are the same as linear motion, but using the rotational quantities. • I can relate linear and rotational quantities.
3 Torque	I can recognize that a force acting through a lever arm, or a torque, can causes a rotation	• I can calculate a torque, and a sum of torques.
4 Static Equilibrium	I can recognize situations in which an object cannot be treated as a point particle.	• I can apply Newton's second law for equilibrium in both the linear and rotational form to build a sufficient number of equations to solve the problem.

Unit Title:	
Simple Harmonic Motion (1201)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• What is simple harmonic motion, and how does it differ from other types of periodic motion? • How can we describe the displacement, velocity, and acceleration of an object undergoing simple harmonic motion using mathematical equations? • What are the connections between simple harmonic motion and the behavior of waves, and how do wave properties apply to oscillating systems? • How can we use energy considerations to analyze and describe simple harmonic motion, and what are the implications for the conservation of energy in oscillatory systems? • How can the principles of simple harmonic motion be applied to solve real-world problems and describe natural phenomena, such as the motion of vibrating strings or the behavior of mechanical systems? • What are the limitations of the simple harmonic motion model, and in what situations might it not accurately represent the behavior of oscillating systems?	Harmonic Motion: • Defining simple harmonic motion as a type of periodic motion where the restoring force is directly proportional to the displacement from equilibrium. • Understanding that many systems in nature exhibit simple harmonic motion. Equations of Motion: • Describing the displacement, velocity, and acceleration of an object undergoing simple harmonic motion using mathematical equations. • Recognizing the sinusoidal nature of these equations. Period and Frequency: • Defining and understanding the period and frequency of simple harmonic motion. • Recognizing the relationship between period and frequency: T=1/f Amplitude: • Defining amplitude as the maximum displacement from equilibrium in simple harmonic motion. Phase: • Understanding the concept of phase in simple harmonic motion, which represents the position of the object in its oscillation cycle. Energy in Simple Harmonic Motion: • Recognizing the interconversion of kinetic and potential energy during the motion. • Understanding how the total mechanical energy remains constant in ideal conditions. Damping and Resonance: • Understanding the effects of damping on simple harmonic motion and recognizing the distinction between underdamped, critically damped, and overdamped systems. • Understanding resonance and its relation to the natural frequency of a system. Simple Pendulum: • Analyzing the simple harmonic motion of a mass-spring system and a simple pendulum. • Understanding the factors affecting the period of a simple pendulum. Hooke's Law:

	• Recognizing Hooke's Law as a fundamental principle governing the restoring force in a mass-spring system. Angular Simple Harmonic Motion: • Understanding angular simple harmonic motion for systems involving rotational motion. Wave Properties: • Recognizing the relationship between simple harmonic motion and wave motion, particularly sinusoidal waves.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Amplitude, angular frequency, elastic potential energy, frequency, harmonic motion, Hertz, Hooke's Law, oscillation, period, pendulum, simple harmonic motion, spring constant	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**
The CELP guidance is to **support the development of language; access to course content expectations should not change as a result of MLL status.* **I can explain the relationship between Hooke's Law and simple harmonic motion.** An EL can conduct research and evaluate and communicate findings to answer questions or solve problems. • Level 1: Through simple activities and guided discussions, I can start from basic sentences to describe how	

Hooke's Law influences the motion of objects attached to springs. • Level 2: I can create simple diagrams to explain the relationship between force and displacement in simple harmonic motion, using vocabulary and sentence structures appropriate for their proficiency level. • Level 3: I can gather information from various sources such as textbooks, articles, and videos to explain how Hooke's Law leads to oscillatory motion in springs. • Level 4: I can conduct more independent research to explore the connection between Hooke's Law and simple harmonic motion. I can write organized responses that demonstrate a thorough understanding of the topic, using appropriate academic language and citing sources accurately. • Level 5: I can critically evaluate complex theories and models, integrating information from diverse sources to construct sophisticated explanations of the relationship between Hooke's Law and simple harmonic motion.

Lesson Sequence	**Learning Target**	**Success Criteria**
1 Springs	*I can recognize that a spring exerts a linear restoring force.*	• I can use Hooke's Law to relate force and elongation of a spring. • I can solve problems involving spring potential energy
2 Simple Harmonic Motion	I can recognize that Hooke's Law causes simple harmonic motion.	• I can calculate the period and frequency of a simple harmonic motion.

Unit Title:	
Thermal Physics (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
	Temperature: • Understanding temperature as a measure of the average kinetic energy of particles in a substance. • Recognizing the Celsius and Kelvin temperature scales. Thermal Equilibrium and Zeroth Law: • Defining thermal equilibrium and understanding the Zeroth Law of Thermodynamics. • Recognizing how the concept of temperature is related to thermal equilibrium. Heat and Internal Energy: • Defining heat as energy transfer due to temperature differences. • Understanding internal energy as the sum of the microscopic kinetic and potential energies of particles in a substance. Specific Heat and Heat Capacity: • Defining specific heat as the amount of heat required to raise the temperature of a unit mass of a substance by one degree. • Understanding heat capacity as the total heat required to raise the temperature of an object. First Law of Thermodynamics: • Understanding the First Law, which states that the change in internal energy of a system is equal to the heat added to the system minus the work done by the system. Work in Thermodynamics: • Defining work as the transfer of energy from one system to another due to the application of force through a distance. • Recognizing the signs of work done on or by the system. Adiabatic Processes: • Understanding adiabatic processes, where no heat is exchanged with the surroundings. Heat Engines and Efficiency: • Understanding the principles of heat engines and the concept of thermal efficiency. • Recognizing the Carnot cycle as a theoretical limit for the efficiency of heat engines. Entropy:

	• Defining entropy as a measure of the disorder or randomness in a system. • Recognizing that natural processes tend to increase the overall entropy of the universe. Second Law of Thermodynamics: • Understanding the Second Law, which states that the total entropy of an isolated system always increases over time.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Absolute zero, adiabatic process, calorie, calorimetry, coefficient of area expansion, coefficient of volume expansion, convection, first law of thermodynamics, heat, heat of fusion, heat of vaporization, ideal gas law, internal energy, Isobaric process, isovolumetric process, Kelvin, kinetic theory of gasses, law of equilibrium, law of thermodynamics, latent heat, mechanical equivalent of heat, phase change, radiation, specific heat, temperature, thermal conduction, thermal contact, thermal equilibrium, thermal expansion, thermometer, thermodynamics, triple point.	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**
**The CELP guidance is to support the development of language; access to course content expectations should not*	

change as a result of MLL status.

I can explain how heat is exchanged during a phase change.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

- Level 1: I can identify key vocabulary words such as heat, temperature, phase change, melting, freezing, vaporization, and condensation. Through simple activities and guided discussions, I can start forming basic sentences to describe how heat causes substances to change from one phase to another.
- Level 2: I can observe and describe phase changes in everyday materials such as water, ice, and steam. I can explain the energy transfer involved in melting, freezing, vaporization, and condensation, using vocabulary and sentence structures.
- Level 3: I can gather information from various sources such as textbooks, articles, and multimedia resources to explain the mechanisms of heat transfer during phase transitions.
- Level 4: I can write an organized explanation that demonstrates a thorough understanding of heat exchange, using appropriate academic language.
- Level 5: I can communicate my understanding effectively through well-structured essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology. I can engage in discussions about the implications and applications of heat exchange during phase changes in various contexts.

Lesson Sequence	Learning Target	Success Criteria
1 Heat	I can recognize heat as a form of energy	• I can relate heat added or removed to a change in temperature. • I can solve problems involving thermal energy transferred to other forms
2 Change of State	I can recognize that heat is exchanged during a phase change.	• I can solve problems involving a substance changing state.
3 Thermal expansion	I can relate the change in temperature of a substance to its change in dimension.	• I can solve problems relating change in temperature to change in length

Unit Title:	
Gravitation (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.2, 3.3); Data Analysis (4.1); Argumentation (5.1, 5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• What are the fundamental principles underlying gravitational interactions, and how do they govern the behavior of celestial objects? • How do gravitational forces and fields shape the behavior of objects in orbit around larger bodies, and what factors influence the stability of these orbits? • What is the relationship between gravitational potential, gravitational potential energy, and gravitational field strength, and how do these concepts contribute to our understanding of gravitational interactions?	Law of Universal Gravitation: • Understanding Newton's law of universal gravitation, which states that every particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers. Gravitational Force: • Defining the gravitational force between two objects and recognizing it as a vector quantity. • Understanding the direction of the gravitational force between objects. Gravitational Field: • Defining the gravitational field as the region of space surrounding a massive object where another mass experiences a force due to gravity. • Recognizing that gravitational field strength is the force per unit mass experienced by an object. Weight: • Understanding weight as the force experienced by an object due to gravity. • Recognizing that weight is the product of an object's mass and the acceleration due to gravity: $W = mg$. Gravitational Potential Energy: • Defining gravitational potential energy as the energy associated with an object due to its position in a gravitational field. • Recognizing the relationship between gravitational potential energy, mass, height, and gravitational acceleration. Escape Velocity: • Understanding escape velocity as the minimum velocity an object must have to escape the gravitational influence of a massive body. • Recognizing the factors that influence escape velocity. Kepler's Laws of Planetary Motion: • Understanding Kepler's laws, which describe the motion of planets in elliptical orbits around the Sun. • Recognizing Kepler's first law (elliptical orbits), second law (equal area in equal time), and third law (relationship between orbital period and semi-major

	axis). Satellites and Orbits: • Analyzing the motion of artificial satellites and celestial bodies in orbit around larger objects. • Understanding the conditions required for stable orbits. Gravitational Potential: • Defining gravitational potential as the work done in bringing a unit mass from infinity to a point in a gravitational field. • Recognizing the relationship between gravitational potential and gravitational potential energy. Gravitational Field Strength: • Understanding the relationship between gravitational field strength, mass, and distance from the center of a massive object.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Celestial Body, Ellipse, Escape Velocity, Gravitational Field, Gravitational Field Strength, Gravitational Force, Gravitational Potential, Gravitational Potential Energy, Kepler's Laws of Planetary Motion, Law of Universal, Gravitation, Orbit, Orbital Period, Satellite, Semi-major, Axis, Weight	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	

Related [CELP standards:](#)	Learning Targets:

The CELP guidance is to support the development of language; access to course content expectations should not change as a result of MLL status.

I can explain how heat is exchanged during a phase change.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

- Level 1: I can identify key vocabulary words such as gravity, gravitational field, force, mass, and acceleration. Through simple activities and guided discussions, I can start form basic sentences to describe how gravitational field strength affects the acceleration of objects.
- Level 2: I can engage in activities where they observe and describe the effects of gravity on objects of different masses. I can create simple diagrams to explain the relationship between gravitational field strength and acceleration, using vocabulary and sentence structures appropriate.
- Level 3: I can gather information from various sources such as textbooks, articles, and multimedia resources to explain how gravity influences the motion of objects. I can paraphrase key information and present it in written or oral reports, incorporating illustrations or diagrams to enhance comprehension.
- Level 4: I can conduct more independent research to explore the relationship between gravitational field strength and acceleration due to gravity in greater depth. I can analyze information from multiple sources and synthesize their findings into coherent explanations.
- Level 5: I can communicate my understanding effectively through articulate and well-structured essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology. I can engage in discussions and debates about the implications and applications of gravitational field strength and acceleration in various contexts.

Lesson Sequence	Learning Target	Success Criteria
1 Gravitational force	I can solve problems using Newton's Law of Universal Gravitation.	• I can relate gravitational force to mass and distance between centers. • I relate how force varies with distance
2 Gravitational field	I can derive an expression for gravitational field strength.	• I can relate gravitational field strength to acceleration of gravity.

Unit Title:	
Electricity and Magnetism (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How do electric and magnetic fields interact to produce forces and influence the behavior of charged particles? • What are the fundamental principles underlying circuits and the flow of electric current, and how do these principles govern the behavior of electrical components? • How do electromagnetic phenomena, including electromagnetic induction and Maxwell's Equations, contribute to our understanding of electricity, magnetism, and light?	Coulomb's Law and Electric Fields: • Electric force between charged objects is determined by Coulomb's Law. • Electric fields describe the influence a charge has on the space around it. Gauss's Law: • Gauss's Law relates the electric flux through a closed surface to the charge enclosed by that surface. Electric Potential: • Electric potential difference is related to the work done by an external force in moving a charge. Capacitance and Dielectrics: • Capacitance measures the ability of a system to store electric charge. • The effect of dielectrics on capacitance. Current, Resistance, and DC Circuits: • Current is the flow of charge; it is related to drift velocity and current density. • Resistance is related to both the material and the geometry of an object. • Ohm's Law governs the relationship between current, voltage, and resistance. • DC circuits involving resistors, capacitors, and inductors. Magnetic Fields and Forces: • Magnetic fields are created by moving charges. • Magnetic forces on moving charges and current-carrying wires. Magnetic Induction: • Faraday's Law describes how a changing magnetic field induces an electromotive force (EMF) in a loop of wire. • Lenz's Law determines the direction of induced currents. AC Circuits: • Alternating current involves time-varying voltage and current. • Impedance and resonance in AC circuits. Maxwell's Equations: • Maxwell's Equations describe the fundamental principles of classical electromagnetism. • The role of electromagnetic waves in understanding

<table>
<tr><td></td><td>light.</td></tr>
<tr><td>Demonstration of Learning:</td><td>Pacing for Unit</td></tr>
<tr><td>University of Connecticut released assessments</td><td>4 weeks</td></tr>
<tr><td>Unit-specific Vocabulary:</td><td>Aligned Unit Materials, Resources, and Technology (beyond core resources):</td></tr>
<tr><td>Ampere’s Law, Capacitors, Circuits, Conductors, , Dielectric, Drift velocity, Electric Charge, Electric current, Electric field, Electric field lines, Electric flux, Electric force, Electric potential, Electrostatic equilibrium, Electronvolt, Equipotential surface, Faraday's Law, Ferromagnetic, Flux, Gauss’ Law, Induced current, Induced emf, Inductance, Induction, Insulators, Kilowatt hour, Lenz’s Law, Magnetic field line, Magnetic flux, Magnetic torque, Ohm’s Law, Ohmic, Permanent magnet, Poles, Polarization, Power, RC circuit, Resistivity, Resistors, Self-induction, Series, Parallel, Solenoid,Time constant, Voltage.</td><td></td></tr>
<tr><td colspan="2">Differentiation through <u>Universal Design for Learning</u></td></tr>
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<tr><td colspan="2">Supporting Multilingual/English Learners</td></tr>
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<tr><td colspan="2">*The CELP guidance is to support the development of language; access to course content expectations should not change as a result of MLL status.

I can define and use the definition of capacitance.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.
Level 1: I can identify key vocabulary words such as capacitance, charge, voltage, and capacitor. Through simple activities and guided discussions, I can form basic sentences to define capacitance and its relation to charge</td></tr>
</table>

and voltage, with assistance as needed.

- Level 2: I can engage in activities where they observe and describe simple capacitor circuits. I can create diagrams to explain the definition of capacitance and its practical applications, using appropriate vocabulary and sentence structures.
- Level 3: I can gather information from various sources such as textbooks, articles, and online resources to explain capacitance in different contexts. I can paraphrase key information and present it in written or oral reports, using illustrations or diagrams to aid comprehension.
- Level 4: I can analyze information from multiple sources and synthesize findings into coherent explanations. I can write organized essays or deliver presentations that demonstrate a thorough understanding of capacitance, using academic language and citing sources accurately.
- Level 5: I can communicate my understanding effectively through articulate essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology.

Lesson Sequence	**Learning Target**	**Success Criteria**
1 Static Electricity Force and charge	I can define and use the basic concepts of electricity.	• I can define and state the origins and characteristics of electric charge. • I can calculate the net force between point charges.
2 Electric Field		• I can calculate the electric field of a collection of point charges. • I can calculate the electric field between charged parallel plates. • I can calculate the force on a charged point particle due to an electric field.
3 Electric potential/ potential energy	I can recognize there is potential energy associated with a system of charges.	• I can calculate electric potential energy. • I can make energy calculations involving charges. • I can relate electric potential with electric potential energy. • I can make calculations involving potential differences. • I can recognize that a potential difference can cause charges to move.
4 Capacitance	I can define and use the definition of capacitance.	• I can make calculations using charged parallel plates.

Unit Title:	
Electric Current and Circuits (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4); Mathematical Routines (2.1, 2.2); Experimental Methods (3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How do electric charge and its quantization form the fundamental basis of electrical phenomena? • What are the fundamental principles underlying electric current, and how does its flow relate to the scalar quantity and direction? • What are the foundational components and principles that govern electrical circuits, and how do they interact to determine circuit behavior?	Electric Charge: • Understanding the concept of electric charge and the quantization of charge. Electric Current: • Defining electric current as the flow of electric charge. • Recognizing that current is a scalar quantity and understanding the direction of current flow. Circuits: • Understanding the basic components of electrical circuits, including resistors, capacitors, and batteries. • Describing the difference between open and closed circuits. Ohm's Law: • Understanding Ohm's Law, which relates the voltage across a conductor to the current flowing through it: V=IR Resistors and Resistance: • Defining resistance and recognizing factors that affect resistance. • Understanding how to calculate total resistance in series and parallel resistor configurations. Power in Electric Circuits: • Understanding the concept of electrical power and its relationship to voltage and current P=IV Kirchhoff's Laws: • Applying Kirchhoff's laws (Kirchhoff's loop rule and Kirchhoff's junction rule) to analyze complex circuits. Capacitors in Circuits: • Understanding the behavior of capacitors in circuits and how they store and release electrical energy. Series and Parallel Circuits: • Analyzing and understanding the characteristics of series and parallel circuits. • RC Circuits: Analyzing circuits containing resistors and capacitors (RC circuits). • Understanding the time constant and the charging/discharging process of a capacitor in an RC circuit. Meters and Measurements: • Using meters to measure current, voltage, and

	resistance in circuits.
Demonstration of Learning:	**Pacing for Unit**
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Capacitor, Circuit Diagram, Conductor, Coulomb's Law, Current, Direct Current (DC), Electric Current, Electric Potential Difference, Inductor, Insulator, Kirchhoff's rules, Ohm's Law, Parallel Circuit, Power, Resistor, Resistance, Series Circuit, Superconductor, Voltage, Magnetic Field, Magnetic Forces, Alternating Current (AC), Capacitor, Circuit Diagram, Conductor, Coulomb's Law, Current, Direct Current (DC), Electric Power Grid, Electric Current, Electric Potential Difference, Inductor, Insulator, Kirchhoff's Laws, Ohm's Law, Parallel Circuit, Power, Resistor, Resistance, Series Circuit, Superconductor, Voltage.	
Differentiation through *Universal Design for Learning*	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related *CELP standards:*	**Learning Targets:**
The CELP guidance is to support the development of language; access to course content expectations should not change as a result of MLL status.* **I can explain the conditions required for magnetism to create electric currents. An EL can conduct research and evaluate and communicate findings to answer questions or solve problems. • I can identify key vocabulary words such as magnetism, electric current, conductor, and generator. Through simple activities and guided discussions, I can form basic sentences to describe the relationship between	

magnetism and electric currents, with assistance as needed.

- Level 2: I can engage in activities where I observe and describe basic electromagnetic phenomena. I can create diagrams to explain how motion or changes in magnetic fields induce electric currents, using appropriate vocabulary and sentence structures.
- Level 3: I can gather information from various sources such as textbooks, articles, and online resources to explain electromagnetic induction in different contexts. I can paraphrase key information and present it in written or oral reports, using illustrations or diagrams to aid comprehension.
- Level 4: I can analyze information from multiple sources, evaluate the reliability of each source, and synthesize their findings into coherent explanations. I can write organized essays or deliver presentations that demonstrate a thorough understanding of the conditions required for magnetism to create electric currents, using academic language and citing sources accurately.
- Level 5: I can critically evaluate complex theories and models, integrate information from diverse sources, and construct sophisticated explanations. I can communicate my understanding effectively through articulate essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology.

Lesson Sequence	**Learning Target**	**Success Criteria**
1 Electric Currents	*I can define electric current.*	• I can relate charge current and time.
2 Resistance	I can identify resistance as an opposition to current.	• I can use Ohm's Law to relate current voltage and resistance. • I can calculate the resistance of an object. • I can calculate the power dissipated by a circuit.
3. Electric Circuits	I can calculate resistance, current, power, voltage, and capacitance of an electric circuit.	• I can make calculations with resistors in series, parallel, and combination connections. • I can properly connect voltmeters and ammeters. • I can construct circuits in the lab given a schematic diagram. • I can analyze circuits with capacitors connected in various ways. • I can properly treat capacitors in circuits immediately after it is energized and at steady state.
Magnetostatics	I can analyze the magnetic force on a moving charge in a magnetic field.	• I can calculate the force on a moving charge in a magnetic field, and determine the resulting motion of the charge. • I can calculate the force on a current-carrying conductor in a magnetic field. • I can calculate the magnetic field of a straight current carrying conductor.
Electrodynamics	I can understand the conditions required for magnetism to create electric currents.	• I can calculate magnetic flux. • I can quantify the relationship between changing magnetic flux and induced voltage. • I can use Lenz's Law to determine the direction of the induced current.

Unit Title:	
Waves and Optics (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4); Mathematical Routines (2.1, 2.2); Experimental Methods (3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How do waves propagate and interact, and what are the key characteristics that define their behavior? • How does light behave as it travels through different mediums and interacts with surfaces, mirrors, and lenses? • What evidence supports the wave-particle duality of light, and how does this duality manifest in various optical phenomena?	**Waves:** Wave Characteristics: • Understanding the nature of waves, including amplitude, wavelength, frequency, and wave speed. • Recognizing the distinction between transverse and longitudinal waves. Wave Interactions: • Exploring the principles of interference, both constructive and destructive, in the context of waves. • Understanding standing waves and their formation. Doppler Effect: • Understanding how the observed frequency of a wave changes when the source or observer is in motion. **Optics:** Reflection and Refraction: • Applying the laws of reflection and refraction to understand how light interacts with surfaces and changes direction. • Mirrors and Lenses: • Understanding the behavior of convex and concave mirrors, as well as convex and concave lenses. • Analyzing how mirrors and lenses form images and how image characteristics are determined. Ray Optics: • Applying ray optics to describe the behavior of light as rays. Diffraction and Polarization: • Understanding diffraction as the bending of waves around obstacles. • Recognizing polarization as the orientation of oscillations in a transverse wave. Interference and Young's Double-Slit Experiment: • Understanding the phenomenon of interference and applying it to analyze patterns created by multiple sources of light. Thin-Film Interference: • Understanding how interference occurs in thin films and its impact on the colors observed. Wave Nature of Light: • Recognizing the dual nature of light as both a wave and a particle.

Demonstration of Learning:	Pacing for Unit
University of Connecticut released assessments	4 weeks
Unit-specific Vocabulary:	**Aligned Unit Materials, Resources, and Technology (beyond core resources):**
Amplitude, Concave Lens, Diffraction, Doppler Effect, Electromagnetic Wave, Focal Length, Focal Point, Frequency, Interference, Lens, Longitudinal Wave, Mechanical Wave, Mirror, Optical Instruments, Period, Polarization, Ray Optics, Refraction, Standing Wave, Transverse Wave, Wavelength, Wave, Wave Equation, Wave Speed.	
Differentiation through Universal Design for Learning	
UDL Indicator	**Teacher Actions:**
Representation: Clarify vocabulary and symbols	• Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge • Provide graphic symbols with alternative text descriptions • Highlight how complex terms, expressions, or equations are composed of simpler words or symbols • Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations) • Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)
Supporting Multilingual/English Learners	
Related CELP standards:	**Learning Targets:**
The CELP guidance is to support the development of language; access to course content expectations should not change as a result of MLL status.* **I can explain how diffraction patterns prove that light has wave properties. An EL can conduct research and evaluate and communicate findings to answer questions or solve problems. • Level 1: I can identify key vocabulary words such as diffraction, light, waves, pattern, and proof. Through simple activities and guided discussions, I can begin forming basic sentences to describe how patterns are formed when light waves encounter obstacles. • Level 2: I can participate in activities where I observe and describe basic diffraction phenomena. I can create diagrams to explain how diffraction patterns provide evidence of light behaving like waves, using appropriate vocabulary and sentence structures. • Level 3: I can gather information from various sources such as textbooks, articles, and online resources to explain diffraction in different contexts. I can paraphrase key information and present it in written or oral reports, using illustrations or diagrams to aid comprehension.	

- Level 4: I can analyze information from multiple sources, evaluate the reliability of each source, and synthesize their findings into coherent explanations. I can write organized essays or deliver presentations that demonstrate a thorough understanding of how diffraction patterns provide evidence of light's wave properties, using academic language and citing sources accurately.
- Level 5: I can critically evaluate complex theories and models, integrate information from diverse sources, and construct sophisticated explanations. I can communicate my understanding effectively through articulate essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology.

Lesson Sequence	**Learning Target**	**Success Criteria**
1 Wave basics	I can understand wave motion	• I can appreciate that wave motion is the motion of a form. • I can relate the frequency, wavelength, and speed of a wave • I can calculate the amplitude of overlapping waves
2 Mechanical waves	I can understand the origin of standing waves and calculate their details.	• I can identify parts of standing waves • I can predict the resonant modes of a standing wave • I can relate wave properties to the properties of sound
3. Light	I can recognize visible light as a part of the electromagnetic spectrum	• I can identify the parts of the electromagnetic spectrum • I can relate wavelength to color • I can analyze the behavior of light striking an interface between two media
4. Geometric optics	I can identify situations when light can form an image	• I can locate the foci of an optical element. • I can use ray tracing to locate images and determine their properties • I can use analytical methods to locate images and determine their properties. • I can differentiate between real and virtual images.
5. Physical optics	I can predict the properties of light based on interference patterns	• I can use Young's Equation to calculate the wavelength of light. • I can understand how diffraction patterns prove that light has wave properties.

Unit Title:	
Modern Physics (1202)	
Relevant Standards: Bold indicates priority	
AP Science Practices: Modeling (1.1, 1.2, 1.3, 1.4, 1.5); Mathematical Routines (2.1, 2.2); Experimental Methods (3.1, 3.2, 3.3); Data Analysis (4.1, 4.3); Argumentation (5.1, 5.2); Making Connections (6.1)	
Essential Question(s):	**Enduring Understanding(s):**
• How do the wave-particle duality of light and matter shape our understanding of the universe? • What are the underlying principles that govern atomic structure and behavior, and how have they evolved over time? • What role does nuclear physics play in shaping our understanding of matter, energy, and the universe?	Dual Nature of Light and Matter: • Light and matter exhibit both wave-like and particle-like behavior, as demonstrated by phenomena such as the photoelectric effect and atomic spectra. • Understanding the wave-particle duality is essential for explaining various phenomena in modern physics. Evolution of Atomic Models: • Historical atomic models, including the Rutherford and Bohr models, represent milestones in understanding the structure of the atom. • Each atomic model builds upon previous ones and introduces new concepts to explain experimental observations. Quantum Mechanics: • Quantum mechanics provides a framework for understanding the behavior of particles at the atomic and subatomic levels. • Concepts such as quantized energy levels and wave functions are fundamental to explaining atomic phenomena. Nuclear Physics: • The structure and stability of atomic nuclei are determined by the balance between nuclear forces and electromagnetic forces. • Nuclear reactions, including decay processes and fusion reactions, involve changes in nuclear energy and mass. Applications of Modern Physics: • Knowledge of modern physics principles underlies various technological applications, such as nuclear energy generation and medical imaging. • Understanding the principles of modern physics enables the development of innovative technologies and solutions to real-world problems. Interdisciplinary Connections: • Modern physics concepts have interdisciplinary connections with other scientific fields, such as chemistry, engineering, and materials science. • Integration of modern physics principles enhances our understanding of natural phenomena and drives advancements in multiple scientific disciplines.

<table>
<tr><th>Demonstration of Learning:</th><th>Pacing for Unit</th></tr>
<tr><td>University of Connecticut released assessments</td><td>6 weeks</td></tr>
<tr><th>Unit-specific Vocabulary:</th><th>Aligned Unit Materials, Resources, and Technology (beyond core resources):</th></tr>
<tr><td>Alpha Decay, Atomic Spectra, Binding Energy, Bohr Model, Conservation of Energy, Electromagnetic Spectrum, Fission, Fusion, Isotope, Mass Defect, Nuclear Decay, Photoelectric Effect, Quantum Mechanics, Rutherford Model, Wave-Particle Duality</td><td></td></tr>
<tr><th colspan="2">Differentiation through <u>Universal Design for Learning</u></th></tr>
<tr><th>UDL Indicator</th><th>Teacher Actions:</th></tr>
<tr><td>Representation: Clarify vocabulary and symbols</td><td>

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<tr><th>Related <u>CELP standards:</u></th><th>Learning Targets:</th></tr>
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I can explain how classical physics is insufficient to accurately describe all aspects of light's behavior.
An EL can conduct research and evaluate and communicate findings to answer questions or solve problems.

Level 1: I can identify key vocabulary words such as classical physics, light, behavior, and limitations. Through simple activities and guided discussions, I can form basic sentences to describe how classical physics fails to fully explain certain properties of light.
Level 2: I can engage in activities where I observe and describe basic phenomena that classical physics cannot fully account for, such as the photoelectric effect or the wave-particle duality of light. I can create diagrams to explain these limitations, using appropriate vocabulary and sentence structures.
Level 3: I can gather information from various sources such as textbooks, articles, and online resources to explain phenomena that classical physics cannot adequately describe, such as interference patterns in the double-slit experiment or the polarization of light. I can paraphrase key information and present it in written or oral reports, using illustrations or diagrams to aid comprehension.
Level 4: I can analyze information from multiple sources, evaluate the reliability of each source, and synthesize
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their findings into coherent explanations. I can write organized essays or deliver presentations that demonstrate a thorough understanding of why classical physics is insufficient to fully describe light's behavior, using academic language accurately. • Level 5: I can critically evaluate complex theories and models, integrate information from diverse sources, and construct sophisticated explanations. I can communicate my understanding effectively through articulate essays, presentations, or scientific reports, demonstrating fluency in academic language and precise terminology.		

Lesson Sequence	**Learning Target**	**Success Criteria**
1	I can appreciate that classical physics is insufficient to accurately describe all aspects of light's behavior.	• I can name photoelectric effect as a phenomena that cannot be explained by the wave model of light • I can list several aspects of the photoelectric effect that cannot be explained by the wave model. • I can name atomic spectra as an example of a phenomenon that cannot be explained by the wave model of light.
2	I can explain how the particle model of light can fully explain the photoelectric effect.	• I can solve problems relating photon energy to frequency. • I can apply conservation of energy to calculate photoelectron energy. • I can relate cutoff frequency to target electron work function.
3	I can understand the wave/particle duality of light.	• I can appreciate that light sometimes acts like a wave and sometimes acts like a particle.
4	I can appreciate the need for revised models of the atom	• I can give a brief synopsis of historical atomic models and their limitations • I can understand how the Rutherford model of the atom explains the scattering of the gold foil experiment
5	I can understand the structure of the Bohr Model of the atom.	• I can understand the Bohr atom as a planetary model with additional assumptions that provide for quantized electron energy levels. • I can predict the wavelength of light emitted or absorbed by hydrogen atoms. • I can state the limitations of the Bohr model of the atom.
6	I can understand the wave/particle duality of matter.	• I can appreciate that matter sometimes acts like a wave and sometimes acts like a particle. • I can relate the wavelength of a particle to its momentum. • I can use the wave nature of matter to improve the bohr model of the atom.
7	I can understand nuclear structure	• I can state the constituents of a nucleus • I can understand that the number of protons determines the element and the number of neutrons determines the isotope. • I can understand why some nuclei are stable and why others are radioactive.

8	I can understand that mass can be converted into energy	• I can relate the mass defect to binding energy • I can relate the loss of nuclear mass to the emission of a high energy photon. • I can relate binding energy to nuclear stability.
9	I can understand the nuclei change spontaneously by nuclear decay.	• I can recognize and write reactions for alpha and beta decay. • I can relate gamma decay to nuclear energy levels. • I can calculate the change in nuclear energy during reactions.
10	I can understand the process of a nuclear fission chain reaction.	• I can state the role of fission reactor components. • I can relate mass lost in reactions to energy produced.
11	I can understand the process of a nuclear fusion reaction.	• I can state the role of fusion reactor components. • I can relate mass lost in reactions to energy produced.