TOWNSHIP OF UNION PUBLIC SCHOOLS

SC 430
AP Physics 1
Curriculum Guide
January 2019

Mission Statement

The mission of the Township of Union Public Schools is to build on the foundations of honesty, excellence, integrity, strong family, and community partnerships. We promote a supportive learning environment where all students are challenged, inspired, empowered, and respected as diverse learners. Through cultivation of students' intellectual curiosity, skills and knowledge, our students can achieve academically and socially as well as contribute as responsible and productive citizens of our global community.

Philosophy Statement

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is the formulation of a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

Statement of District Goals

- Develop reading, writing, speaking, listening, and mathematical skills.
- Develop a pride in work and a feeling of self-worth, self-reliance, and self-discipline.
- Acquire and use the skills and habits involved in critical and constructive thinking.
- Develop a code of behavior based on moral and ethical principles.
- Work with others cooperatively.
- Acquire a knowledge and appreciation of the historical record of human achievement and failures and current societal issues.
- Acquire a knowledge and understanding of the physical and biological sciences.
- Participate effectively and efficiently in economic life and the development of skills to enter a specific field of work.
- Appreciate and understand literature, art, music, and other cultural activities.
- Develop an understanding of the historical and cultural heritage.
- Develop a concern for the proper use and/or preservation of natural resources.
- Develop basic skills in sports and other forms of recreation.

Course Description

The premise of the revised AP Physics 1 course is to more closely mirror the expectations, rigor, and content of an introductory college-level physics course by exposing students to a broader range of instructional activities. Students benefit from a reduction in the number of learning objectives, as it provides more time to develop and refine deeper understandings of the principles and strategies of inquiry and critical thinking that are a part of any post-secondary physics course. The AP Physics 1 course is built upon fundamental concepts called enduring understandings and their application by way of the science practices. These concepts are the foundation of the curriculum and support the overarching themes of AP Physics 1, called the big ideas.

The role of the teacher as a lecturer responsible for complete content presentation has shifted toward that of facilitator, with the challenging task of guiding students to discover, develop, and refine the enduring understandings of higher-level physics by participating in activities that promote inquiry, critical thinking, experimental design, and data analysis. With this pedagogical shift comes a greater emphasis on learning by doing and a diminished focus on lectures and mathematical routines. The course requires that students spend 25 percent of instructional time engaged in laboratory activities where the seven science practices are emphasized. Students keep a laboratory notebook in which they record their observations, data, and final lab reports.

There will be instances where the basic concepts necessary for an inquiry based activity are addressed outside of the classroom — allowing students to utilize all available resources, including the collaborative efforts and creative input of their peers. One interesting aspect of this revised approach is the opportunity and means to extend the learning process. The possibility of extending an activity feeds the innate curiosity of young adults, and it fosters the inevitable crossover into other science and math disciplines and exposure to careers in the sciences.

Course Proficiencies

Students will be able to…

1. Read, interpret and display graphical information.
2. Design experiments, execute them and interpret the results.
3. Use Kinematics equations to solve conceptual and quantitative problems in one and two dimensions.
4. Have a strong conceptual and mathematical knowledge of Newton's Laws of motion.
5. Use their knowledge of the transformation of energy to interpret the world around them.
6. Use skills and equations to understand the fundamental forces that drive the universe.
7. Explain mathematically and conceptually the different types of waves and how waves propagate.
8. Demonstrate mathematically and conceptually the connection between linear and rotational motion.
9. Explain mathematically and conceptually problems relating to momentum.
10. Relate Newton's law of gravitation to both celestial and terrestrial phenomena.
11. Explain mathematically and conceptually the concepts of Electricity, Charge and Resistance.

Recommended Text

Giancoli, D.C. Physics: Principles with Applications. Englewood Cliffs, NJ: Prentice Hall.

Units

Unit 1: Kinematics

Unit 2: Dynamics

Unit 3: Circular Motion and Gravitation

Unit 4: Energy

Unit 5: Momentum

Unit 6: Simple Harmonic Motion

Unit 7: Rotational Motion

Unit 8: Mechanical Waves

Unit 9: Electrostatics

Unit 10: DC Circuits

Pacing Guide

Content	Weeks
Unit 1: Kinematics	6
Unit 2: Dynamics	7
Unit 3: Circular Motion and Gravitation	2
Unit 4: Energy	4
Unit 5: Momentum	2
Unit 6: Simple Harmonic Motion	3
Unit 7: Rotational Motion	4
Unit 8: Mechanical Waves	3
Unit 9: Electrostatics	1
Unit 10: DC Circuits	2

Unit 1: Kinematics

GIANCOLI (7e): Chapter 2 (2-1 through 2-8) and Chapter 3 (3-1, 3-4 through 3-6, 3-8)

- Reference Frames and Displacement
- Average Velocity and Instantaneous Velocity
- Motion at Constant Acceleration
- Falling Objects
- Adding Vectors by Components
- Projectile Motion: projectiles fired horizontally and at an angle
- Graphical Analysis of Motion

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.A.1.1: The student is able to express the motion of an object using narrative, mathematical, and graphical representations. [SP 1.5, 2.1, 2.2]

3.A.1.2: The student is able to design an experimental investigation of the motion of an object. [SP 4.2]

3.A.1.3: The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations. [SP 5.1]

Guiding Questions

How are multiple representations (i.e., words, graphs, and equations) used to describe an object’s motion?
How do scalar measurements differ from vector measurements?
How are kinematics equations and graphs used to describe objects in free fall?
Why is knowledge of vectors and component calculation vital to understanding two-dimensional motion?
How are the kinematics equations applied to objects experiencing motion in two dimensions?
How do variables such as launch angle, velocity, and altitude affect the maximum height and range of a launched projectile?
What do we mean when we say that the horizontal motion of a projectile is independent of its vertical motion?

<table>
<tr><th>Learning Objective</th><th>Activities / Assessment</th></tr>
<tr><td>Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2]</td><td rowspan="5">Laboratory Investigations
Graph Matching
Graphical Analysis of Motion
Cart on a Ramp
Indirect Measurement of Height Using Kinematics
Determining g on an Incline
Displacement Vectors
Horizontally Launched Projectiles
Projectiles Launched at an Angle

Questioning
Exit Slips
Homework/Classwork
PHET Simulations
Quizzes
Tests
AP Practice Questions</td></tr>
<tr><td>Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. [LO 3.A.1.3, SP 5.1]</td></tr>
<tr><td>Design an experimental investigation of the motion of an object. [LO 3.A.1.2, SP 4.2]</td></tr>
<tr><td>Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [LO 3.A.3.1, SP 6.4, SP 7.2]</td></tr>
<tr><td>Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2]</td></tr>
</table>

Unit 2: Dynamics

GIANCOLI (7e): Chapter 4 (4-1 through 4-8)

- Forces
- Free-Body-Diagrams
- Newton's Laws of Motion
- Mass and Weight
- Applications Involving Friction, Inclines

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

1.C.1.1: The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object its inertial mass and its acceleration. [SP 4.2]

1.C.3.1: The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments. [SP 4.2]

BIG IDEA 2: Fields existing in space can be used to explain interactions.

2.B.1.1: The student is able to apply F=mgto calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [SP 2.2, 7.2]

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1]

3.A.3.1: The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [SP 6.4, 7.2]

3.A.3.2: The student is able to challenge a claim that an object can exert a force on itself. [SP 6.1]

3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4]

3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2]

3.A.4.2: The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2]

3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. [SP 1.4]

3.B.1.1: The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension. [SP 6.4, 7.2]

3.B.1.2: The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. [SP 4.2, 5.1]

3.B.1.3: The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [SP 1.5, 2.2]

3.B.2.1: The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [SP 1.1, 1.4, 2.2]

3.C.4.1: The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces. [SP 6.1]

3.C.4.2: The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [SP 6.2]

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.A.1.1 The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively. [SP 1.2, 1.4, 2.3, 6.4]

4.A.2.1: The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time. [SP 6.4]

4.A.2.2: The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. [SP 5.3]

4.A.2.3: The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system. [SP 1.4, 2.2]

4.A.3.1: The student is able to apply Newton’s second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system. [SP 2.2]

4.A.3.2: The student is able to use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system. [SP 1.4]

Guiding Questions

What is Newton's first law and how does it explain static equilibrium?
How is knowledge of the net force essential to understanding an object's constant velocity?
How do free-body diagrams assist in problem solving for Newton's laws of motion?
How does the presence of a net force determine the acceleration of an object?
What is the nature of friction and how does it factor into an object's acceleration?
How can an Atwood's machine be used to calculate the acceleration of gravity? What considerations must be made when a system is composed of two or more objects?
Why is the Atwood machine an exemplar for systems of masses?
What are action-reaction force pairs? And do they cancel each other?

Learning Objective	**Activities / Assessment**
Describe a force as an interaction between two objects and identify both objects for any force. [LO 3.A.3.3, SP 1.4]	**Laboratory Investigations** Atwood's Machine Modified Atwood Machines Third Law in the Real World Factors Affecting Acceleration Inertial vs. Gravitational Mass Apparent Weight Dragging a Shoe Net Force Newton's Second Law Friction, Inclination, and String Tension Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Make claims about various contact forces between objects based on the microscopic cause of those forces. [LO 3.C.4.1, SP 6.1]	
Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [LO 3.C.4.2, SP 6.2]	
Challenge a claim that an object can exert a force on itself. [LO 3.A.3.2, SP 6.1]	
Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [LO 3.A.2.1, SP 1.1]]	
Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [LO 3.B.2.1, SP 1.4, SP 2.2]	
Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [LO 3.A.3.1, SP 6.4, SP 7.2]	
Predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of	

physical situations with acceleration in one dimension. [LO 3.B.1.1, SP 6.4, SP 7.2]	
Apply F m= g to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [LO 2.B.1.1, SP 2.2, SP 7.2]	
Model verbally or visually the properties of a system based on its substructure and to relate this to changes in the system properties over time as external variables are changed. [LO 1.A.5.1, SP 1.1, SP 7.1]	

Unit 3: Circular Motion and Gravitation

GIANCOLI (7e): Chapter 5 (5-1, 5-2 and 5-5 through 5-8)

- Kinematics of Uniform Circular Motion
- Dynamics of Uniform Circular Motion
- Newton's Law of Universal Gravitation
- Gravity Near the Earth's Surface
- Satellites and "Weightlessness"
- Kepler's Laws

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

1.C.3.1: The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments. [SP 4.2]

BIG IDEA 2: Fields existing in space can be used to explain interactions.

2.B.1.1: The student is able to apply F=mgto calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [SP 2.2, 7.2]

2.B.2.1: The student is able to apply $g=GMr2$to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M. [SP 2.2]

2.B.2.2: The student is able to approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects. [SP 2.2]

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1]

3.A.3.1: The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [SP 6.4, 7.2]

3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4]

3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton’s third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2]

3.A.4.2: The student is able to use Newton’s third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2]

3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton’s third law to identify forces. [SP 1.4]

3.B.1.2: The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. [SP 4.2, 5.1]

3.B.1.3: The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [SP 1.5, 2.2]

3.B.2.1: The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [SP 1.1, 1.4, 2.2]

3.C.1.1: The student is able to use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion. [SP 2.2]

3.C.1.2: The student is able to use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion [SP 2.2]

3.C.2.2: The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [SP 7.2]

3.G.1.1:The student is able to articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored. [SP 7.1]

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.A.2.2: The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. [SP 5.3]

Guiding Questions

How are multiple representations (i.e., words, graphs, and equations) used to describe an object's motion?
How do scalar measurements differ from vector measurements?
How are kinematics equations and graphs used to describe objects in free fall?
Why is knowledge of vectors and component calculation vital to understanding two-dimensional motion?
How are the kinematics equations applied to objects experiencing motion in two dimensions?
How do variables such as launch angle, velocity, and altitude affect the maximum height and range of a launched projectile?
What do we mean when we say that the horizontal motion of a projectile is independent of its vertical motion?

Learning Objective	Activities / Assessment
Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2]	**Laboratory Investigations** Gravity Force Lab Satellites Orbit Gravity and Orbits
Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. [LO 3.A.1.3, SP 5.1]	

Design an experimental investigation of the motion of an object. [LO 3.A.1.2, SP 4.2]	Flying Toy Lab Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [LO 3.A.3.1, SP 6.4, SP 7.2]	
Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2]	

Unit 4: Energy

GIANCOLI (7e): Chapter 6 (6-1, 6-2 through 6-10)

- Work
- Kinetic Energy and the Work-Energy Theorem
- Potential Energy: Gravitational and Elastic
- Mechanical Energy and its Conservation
- Power

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.E.1.1: The student is able to make predictions about the changes in kinetic energy of an object based on considerations of the direction of the net force on the object as the object moves. [SP 6.4, 7.2]

3.E.1.2: The student is able to use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged. [SP 1.4]

3.E.1.3: The student is able to use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged. [SP 1.4, 2.2]

3.E.1.4: The student is able to apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object. [SP 2.2]

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.C.1.1: The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy. [SP 1.4, 2.1, 2.2]

4.C.1.2: The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. [SP 6.4]

4.C.2.1:The student is able to make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass. [SP 6.4]

4.C.2.2: The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system. [SP 1.4, 2.2, 7.2]

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

5.A.2.1: The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2]

5.B.1.1: The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy. [SP 1.4, 2.2]

5.B.1.2: The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies. [SP 1.5]

5.B.2.1: The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [SP 1.4, 2.1]

5.B.3.1: The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. [SP 2.2, 6.4, 7.2]

5.B.3.2: The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. [SP 1.4, 2.2]

5.B.3.3: The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system. [SP 1.4, 2.2]

5.B.4.1:The student is able to describe and make predictions about the internal energy of systems. [SP 6.4, 7.2]

5.B.4.2: The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [SP 1.4, 2.1, 2.2]

5.B.5.1: The student is able to design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance. [SP 4.2, 5.1]

5.B.5.2: The student is able to design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system. [SP 4.2, 5.1]

5.B.5.3: The student is able to predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance. [SP 1.4, 2.2, 6.4]

5.B.5.4: The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy). [SP 6.4, 7.2]

5.B.5.5: The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance. [SP 2.2, 6.4]

5.D.1.1: The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. [SP 6.4, 7.2]

5.D.1.2: The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations. [SP 2.2, 3.2, 5.1, 5.3]

5.D.1.3: The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy. [SP 2.1, 2.2]

5.D.1.4: The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome. [SP 4.2, 5.1, 5.3, 6.4]

5.D.1.5: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. [SP 2.1, 2.2]

5.D.2.1: The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [SP 6.4, 7.2]

<table>
<tr><td colspan="2">5.D.2.3: The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [SP 6.4, 7.2]</td></tr>
<tr><td colspan="2">Guiding Questions
How is the energy of a system defined?
How is work represented graphically?
What is mechanical energy and what factors affect its conservation?</td></tr>
<tr><td>Learning Objective</td><td>Activities / Assessment</td></tr>
<tr><td>Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [LO 5.A.2.1, SP 6.4, SP 7.2]</td><td rowspan="5">Laboratory Investigations
How Angle of Force Determines the Amount of Work
Measuring the Spring Constant
Do Rubber Bands Obey Hooke’s Law?
Work-Energy Theorem
Energy of a Tossed Ball
Atwood’s Machine and Center of Mass
Friction on a Sliding Object
Questioning
Exit Slips
Homework/Classwork
PHET Simulations
Quizzes
Tests
AP Practice Questions</td></tr>
<tr><td>Make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy). [LO 5.B.5.4, SP 6.4, SP 7.2]</td></tr>
<tr><td>Predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance. [LO 5.B.5.5, SP 2.2, SP 6.4]</td></tr>
<tr><td>Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [LO 3.A.3.1, SP 6.4, SP 7.2]</td></tr>
<tr><td>Design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system. [LO 5.B.5.2, SP 4.2, SP 5.1]</td></tr>
</table>

Unit 5: Momentum

GIANCOLI (7e): Chapter 7 (7-1through 7-6)

- Impulse and Change in Momentum
- Conservation of Momentum
- Conservation of Energy and Momentum in Collisions (1 dimension)
- Conservation of Momentum in Collisions (2 dimensions: qualitative and semi-quantitative only)

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.D.1.1: The student is able to justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force. [SP 4.1]

3.D.2.1: The student is able to justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and time of interaction. [SP 2.1]

3.D.2.2: The student is able to predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [SP 6.4]

3.D.2.3: The student is able to analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [SP 5.1]

3.D.2.4: The student is able to design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time. [SP 4.2]

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.B.1.1: The student is able to calculate the change in linear momentum of a two-object system with constant mass in linear motion from a representation of the system (data, graphs, etc.). [SP 1.4, 2.2]

4.B.1.2: The student is able to analyze data to find the change in linear momentum for a constant-mass system using the product of the mass and the change in velocity of the center of mass. [SP 5.1]

4.B.2.1: The student is able to apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system. [SP 2.2]

4.B.2.2: The student is able to perform analysis on data presented as a force-time graph and predict the change in momentum of a system. [SP 5.1]

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

5.A.2.1: The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2]

5.D.1.1: The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. [SP 6.4, 7.2]

5.D.1.2: The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations. [SP 2.2, 3.2, 5.1, 5.3]

5.D.1.3: The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy. [SP 2.1, 2.2]

5.D.1.4: The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome. [SP 4.2, 5.1, 5.3, 6.4]

5.D.1.5: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. [SP 2.1, 2.2]

5.D.2.1: The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [SP 6.4, 7.2]

5.D.2.2: The student is able to plan data collection strategies to test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically. [SP 4.1, 4.2, 5.1]

5.D.2.3: The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [SP 6.4, 7.2]

5.D.2.4: The student is able to analyze data that verify conservation of momentum in collisions with and without an external friction force. [SP 4.1, 4.2, 4.4, 5.1, 5.3]

5.D.2.5: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values. [SP 2.1, 2.2]

5.D.3.1: The student is able to predict the velocity of the center of mass of a system when there is no interaction outside of the system but there is an interaction within the system (i.e., the student simply recognizes that interactions within a system do not

affect the center of mass motion of the system and is able to determine that there is no external force). [SP 6.4]
Guiding Questions How is the energy of a system defined? How is work represented graphically? What is mechanical energy and what factors affect its conservation?

Learning Objective	**Activities / Assessment**
Analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [LO 3.D.2.3, SP 5.1]	**Laboratory Investigations** Impulse and Momentum 3 weeks Bouncing Darts Conservation of Momentum in Collisions Car Safety Models Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Perform analysis on data presented as a force-time graph and predict the change in momentum of a system. [LO 4.B.2.2, SP 5.1]	
Predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance. [LO 5.B.5.5, SP 2.2, SP 6.4]	
Apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system. [LO 4.B.2.1, SP 2.2]	
Justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and time of interaction. [LO 3.D.2.1, SP 2.1]	
Apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system. [LO 4.B.2.1, SP 2.2]]	
Justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force. [LO 3.D.1.1, SP 4.1	
Predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [LO 3.D.2.2, SP 6.4]	
Qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [LO 5.D.2.1, SP 6.4, SP 7.2]	

Unit 6: Simple Harmonic Motion
GIANCOLI (7e): Chapter 11 (11-1through 11-4)
• Simple Harmonic Motion • SHM Graphs: position, velocity, acceleration, energy • Energy in SHM • Mass-Spring Systems • Simple Pendulum
BIG IDEA 3: The interactions of an object with other objects can be described by forces. 3.B.3.1: The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. [SP 6.4, 7.2] 3.B.3.2: The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. [SP 4.2] 3.B.3.3: The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown. [SP 2.2, 5.1] 3.B.3.4: The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force. [SP 2.2, 6.2] **BIG IDEA 5:** Changes that occur as a result of interactions are constrained by conservation laws. 5.B.2.1: The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [SP 1.4, 2.1] 5.B.3.1: The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems

with internal potential energy. [SP 2.2, 6.4, 7.2]

5.B.3.2: The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. [SP 1.4, 2.2]

5.B.3.3: The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system. [SP 1.4, 2.2]

5.B.4.1: The student is able to describe and make predictions about the internal energy of systems. [SP 6.4, 7.2]

5.B.4.2: The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [SP 1.4, 2.1, 2.2]

Guiding Questions

What is a simple harmonic oscillator?

What factors affect the period of oscillation for a mass oscillating on a spring and for a simple pendulum?

How does the back-and-forth motion of a box on a spring mirror the motion of a pendulum?

Learning Objective	Activities / Assessment
Construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force. [LO 3.B.3.4, SP 2.2, SP 6.2]	**Laboratory Investigations** Simple Harmonic Oscillator Pendulum Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. [LO 3.B.3.1, SP 6.4, SP 7.2]	
Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. [LO 3.A.1.3, SP 5.1]	
Analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown. [LO 3.B.3.3, SP 5.1]	
Design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. [LO 3.B.3.2, SP 4.2]	
Apply mathematical routines to calculate the change in momentum	

of a system by analyzing the average force exerted over a certain time on the system. [LO 4.B.2.1, SP 2.2]]	
Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. [LO 3.A.1.3, SP 5.1]	
Analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown. [LO 3.B.3.3, SP 5.1]	
Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. [LO 3.B.3.1, SP 6.4, SP 7.2]	

Unit 7: Rotational Motion

GIANCOLI (7e): Chapter 7 (7-8); Chapter 8 (8-1 through 8-8)

- Torque
- Center of Mass (qualitative)
- Rotational Kinematics
- Rotational Dynamics and Rotational Inertia
- Rolling Motion (without slipping)
- Rotational Kinetic Energy
- Angular Momentum and its Conservation

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.F.1.1: The student is able to use representations of the relationship between force and torque. [SP 1.4]

3.F.1.2: The student is able to compare the torques on an object caused by various forces. [SP 1.4]

3.F.1.3: The student is able to estimate the torque on an object caused by various forces in comparison to other situations. [SP 2.3]

3.F.1.4: The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system. [SP 4.1, 4.2, 5.1]

3.F.1.5: The student is able to calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction). [SP 1.4, 2.2]

3.F.2.1: The student is able to make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis. [SP 6.4]:

3.F.2.2: The student is able to plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis. [SP 4.1, 4.2, 5.1]

3.F.3.1: The student is able to predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum. [SP 6.4, 7.2]

3.F.3.2: In an unfamiliar context or using representations beyond equations, the student is able to justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object. [SP 2.1]

3.F.3.3: The student is able to plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object. [SP 4.1, 4.2, 5.1, 5.3]

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.A.1.1The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively. [SP 1.2, 1.4, 2.3, 6.4]

4.D.1.1:The student is able to describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system. [SP 1.2, 1.4]

4.D.1.2: The student is able to plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data. [SP 3.2, 4.1, 4.2, 5.1, 5.3]

4.D.2.1: The student is able to describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems. [SP 1.2, 1.4]

4.D.2.2: The student is able to plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems. [SP 4.2]

4.D.3.1: The student is able to use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. [SP 2.2]

4.D.3.2: The student is able to plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted. [SP 4.1, 4.2]

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

5.E.1.1: The student is able to make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque. [SP 6.4, 7.2]

5.E.1.2: The student is able to make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero. [SP 2.1, 2.2]

5.E.2.1: The student is able to describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Students are expected to do qualitative reasoning with compound objects. Students are expected to do calculations with a fixed set of extended objects and point masses. [SP 2.2]

Guiding Questions

Can the kinematics equations be applied to rotating systems?
How can Newton's law be applied to rotating systems?
How does a net torque affect the angular momentum of a rotating system?

Learning Objective	Activities / Assessment
Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2	**Laboratory Investigations** Angular Kinematics Calculating Torque Truss Lab Rotational Equilibrium Net Torque and Angular Acceleration Net Torque and Change in Angular Momentum Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes
Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time. [LO 4.A.2.1, SP 6.4]	
Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. [LO 3.A.1.3, SP 5.1]	
Express the motion of an object using narrative, mathematical, and graphical representations. [LO 3.A.1.1, SP 1.5, SP 2.1, SP 2.2]	
Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and	

velocity is equal to the change in position per unit time. [LO 4.A.2.1, SP 6.4]	Tests AP Practice Questions
Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. [LO 3.B.1.2, SP 6.4, SP 7.2]	
Use representations of the relationship between force and torque. [LO 3.F.1.1, SP 1.4]	
Compare the torques on an object caused by various forces. [LO 3.F.1.2, SP 1.4]	
Calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction). [LO 3.F.1.5, SP 1.4, SP 2.2]	

Unit 8: Mechanical Waves

GIANCOLI (7e): Chapter 11 (11-7 through 11-12); Chapter 12 (12-4, 12-6, 12-7)

- Wave Motion
- Types of Waves: Transverse and Longitudinal
- Energy Transmitted by Waves: relationship of energy and wave amplitude
- Reflection and Interference of Waves
- Standing Waves
- Sources of Sound:
  - Standing waves for stringed instruments
  - Standing waves for a tube open at both ends and for a tube closed at one end
- Beats
- Doppler Effect (qualitative)

BIG IDEA 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

6.A.1.1: The student is able to use a visual representation to construct an explanation of the distinction between transverse and

longitudinal waves by focusing on the vibration that generates the wave. [SP 6.2] 6.A.1.2: The student is able to describe representations of transverse and longitudinal waves. [SP 1.2] 6.A.2.1:The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples. [SP 6.4, 7.2]: 6.A.3.1:The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. [SP 1.4] 6.A.4.1: The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example. [SP 6.4]
6.B.1.1: The student is able to use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. [SP 1.4, 2.2] 6.B.2.1: The student is able to use a visual representation of a periodic mechanical wave to determine wavelength of the wave. [SP 1.4] 6.B.4.1: The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples. [SP 4.2, 5.1, 7.2] 6.B.5.1: The student is able to create or use a wave front diagram to demonstrate or interpret qualitatively the observed frequency of a wave, dependent upon relative motions of source and observer. [SP 1.4] 6.D.1.1: The student is able to use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses. [SP 1.1, 1.4] 6.D.1.2: The student is able to design a suitable experiment and analyze data illustrating the superposition of mechanical waves (only for wave pulses or standing waves). [SP 4.2, 5.1] 6.D.1.3: The student is able to design a plan for collecting data to quantify the amplitude variations when two or more traveling waves or wave pulses interact in a given medium. [SP 4.2] 6.D.2.1: The student is able to analyze data or observations or evaluate evidence of the interaction of two or more traveling waves in one or two dimensions (i.e., circular wave fronts) to evaluate the variations in resultant amplitudes. [SP 5.1] 6.D.3.1: The student is able to refine a scientific question related to standing waves and design a detailed plan for the experiment that can be conducted to examine the phenomenon qualitatively or quantitatively. [SP 2.1, 3.2, 4.2] 6.D.3.2: The student is able to predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. [SP 6.4] 6.D.3.3: The student is able to plan data collection strategies, predict the outcome based on the relationship under test, perform data analysis, evaluate evidence compared to the prediction, explain any discrepancy and, if necessary, revise the relationship among variables responsible for establishing standing waves on a string or in a column of air. [SP 3.2, 4.1, 5.1, 5.2, 5.3] 6.D.3.4: The student is able to describe representations and models of situations in which standing waves result from the addition of

incident and reflected waves confined to a region. [SP 1.2]
6.D.4.1: The student is able to challenge with evidence the claim that the wavelengths of standing waves are determined by the frequency of the source regardless of the size of the region. [SP 1.5, 6.1]
6.D.4.2: The student is able to calculate wavelengths and frequencies (if given wave speed) of standing waves based on boundary conditions and length of region within which the wave is confined, and calculate numerical values of wavelengths and frequencies. Examples should include musical instruments. [SP 2.2]
6.D.5.1: The student is able to use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats. [SP 1.2]

Guiding Questions

How are velocity, frequency, and wavelength used to describe a wave?
What factors affect how a wave is reflected?
How is it possible for two waves to occupy the same space at the same time?
What conditions are necessary to form a standing wave?

Learning Objective	Activities / Assessment
Describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples. [LO 6.A.2.1, SP 6.4, SP 7.2]	**Laboratory Investigations** Sound Waves and Beats Wave Speed, Wavelength, and Frequency Superposition of Waves Standing Waves Speed of Sound Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. [LO 6.A.1.1, SP 6.2]	
Use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. [LO 6.A.3.1, SP 1.4]	
Explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example. [LO 6.A.4.1, SP 6.4]	
Use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. [LO 6.B.1.1, SP 1.4, SP 2.2]	
Use a visual representation of a periodic mechanical wave to determine wavelength of the wave. [LO 6.B.2.1, SP 1.4]	
Design an experiment to determine the relationship between	

periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples. [LO 6.B.4.1, SP 4.2, SP 5.1, SP 7.2]	
Create or use a wave front diagram to demonstrate or interpret qualitatively the observed frequency of a wave, dependent upon relative motions of source and observer. [LO 6.B.5.1, SP 1.4]	
Use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses. [LO 6.D.1.1, SP 1.1, SP 1.4]	

Unit 9: Electrostatics

GIANCOLI (7e): Chapter 16 (16-1 through 16-5)

- Static Electricity; Electric Charge and its Conservation
- Electric Charge in the Atom
- Charging Processes
- Coulomb's Law

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

1.B.1.1: The student is able to make claims about natural phenomena based on conservation of electric charge. [SP 6.4]

1.B.1.2: The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [SP 6.4, 7.2]

1.B.2.1The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. [SP 6.2]:

1.B.3.1: The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated. [SP 1.5, 6.1, 7.2]

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

3.C.2.1: The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges. [SP 2.2, 6.4]

3.C.2.2: The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [See SP 7.2]

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

5.A.2.1: The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge and linear momentum to those situations. [SP 6.4, 7.2]

Guiding Questions

What is the cause of static electricity?
How are electric forces similar to gravitational forces?
How does an electric circuit demonstrate conservation of charge?
What factors affect the resistance of a wire?

Learning Objective	Activities / Assessment
Make claims about natural phenomena based on conservation of electric charge. [LO 1.B.1.1, SP 6.4]	**Laboratory Investigations** Charges in a Penny The Electroscope Inquiry Circuits and Conservation Laws Questioning Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [LO 1.B.1.2, SP 6.4, SP 7.2]	
Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. [LO 1.B.2.1, SP 6.2]	
Challenge the claim that an electric charge smaller than the elementary charge has been isolated. [LO 1.B.3.1, SP 1.5, SP 6.1, SP 7.2]	
Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [LO 3.C.2.2, SP 7.2]	
Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point	

charges (interactions between collections of electric point charges are not covered in Physics 1 and instead are restricted to Physics 2). [LO 3.C.2.1, SP 2.2]	
Choose and justify the selection of data needed to determine resistivity for a given material. [LO 1.E.2.1, SP 4.1]	
Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum V = 0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [LO 5.B.9.2, SP 6.4, SP 7.2	
Construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule). [LO 5.B.9.1, SP 1.1, SP 1.4]	

Unit 10: DC Circuits
GIANCOLI (7e): Chapter 18 (18-1 through 18-5); Chapter 19 (19-1 through 19-4)
• Electric Current • Ohm's Law: Resistance and Resistors • Resistivity • Electric Power • DC Circuits • Resistors in Series and Parallel • Kirchhoff's Rules (circuits with one battery only) • Internal Resistance as a concept is NOT covered in AP Physics 1
BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure. 1.B.1.1: The student is able to make claims about natural phenomena based on conservation of electric charge. [SP 6.4]

1.B.1.2: The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [SP 6.4, 7.2] 1.E.2.1The student is able to choose and justify the selection of data needed to determine resistivity for a given material. [SP 4.1] **BIG IDEA 5:** Changes that occur as a result of interactions are constrained by conservation laws. 5.B.9.1: The student is able to construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule). [SP 1.1, 1.4] 5.B.9.2: The student is able to apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum \Delta V=0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [SP 4.2, 6.4, 7.2] 5.B.9.3: The student is able to apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch. [SP 2.2, 6.4, 7.2] 5.C.3.1:The student is able to apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed. [SP 6.4, 7.2]: 5.C.3.2:The student is able to design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed. [SP 4.1, 4.2, 5.1] 5.C.3.3: The student is able to use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit. [SP 1.4, 2.2]
Guiding Questions How does an electric circuit demonstrate conservation of charge? What factors affect the resistance of a wire?

Learning Objective	**Activities / Assessment**
Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed. [LO 5.C.3.1, SP 6.4, SP 7.2]	**Laboratory Investigations** Charges in a Penny The Electroscope Inquiry Circuits and Conservation Laws Snap Circuit Creation Questioning
Apply conservation of energy concepts to the design of an	

experiment that will demonstrate the validity of Kirchhoff's loop rule (∑v = 0) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [LO 5.B.9.2, SP 6.4, SP 7.2]	Exit Slips Homework/Classwork PHET Simulations Quizzes Tests AP Practice Questions
Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. [LO 1.B.2.1, SP 6.2]	
Challenge the claim that an electric charge smaller than the elementary charge has been isolated. [LO 1.B.3.1, SP 1.5, SP 6.1, SP 7.2]	
Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [LO 3.C.2.2, SP 7.2]	
Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges (interactions between collections of electric point charges are not covered in Physics 1 and instead are restricted to Physics 2). [LO 3.C.2.1, SP 2.2]	
Choose and justify the selection of data needed to determine resistivity for a given material. [LO 1.E.2.1, SP 4.1]	
Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule (∑ V = 0) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [LO 5.B.9.2, SP 6.4, SP 7.2	
Construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule). [LO 5.B.9.1, SP 1.1, SP 1.4]	

The following standards are threaded throughout all units of the NJSLS-Science:

21st Century Life and Career Standards: Career Awareness, ELD Standards, and Technology Standards.

WIDA ELD Standards: Teaching with Standards | WIDA

WIDA has established language development standards for English and Spanish. These standards represent the language students need to be successful in early childhood programs and Grades K-12.

The first standard, **Social and Instructional Language,** reflects the ways in which students interact socially to build community and establish working relationships with peers and teachers in ways that support learning.

The remaining four standards present ways multilingual learners can communicate information, ideas and concepts necessary for academic success in **Language Arts, Math, Science** and **Social Studies**.

Specifically in Science Standard 4- Language of Science- English Language learners communicate information, ideas and concepts necessary for academic success in the content area of science.

New Jersey Student Learning Standards

Standard 9

21st Century Life and Careers

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world. To address these demands, Standard 9, 21st Century Life and Careers, which includes the 12 Career Ready Practices, establishes clear guidelines for what students need to know and be able to do in order to be successful in their future careers and to achieve financial independence.

Mission: *21st century life and career skills enable students to make informed decisions that prepare them to engage as active citizens in a dynamic global society and to successfully meet the challenges and opportunities of the 21st century global workplace.*

Vision: To integrate 21st Century life and career skills across the K-12 curriculum and to foster a population that:

- Continually self-reflects and seeks to improve the essential life and career practices that lead to success.
- Uses effective communication and collaboration skills and resources to interact with a global society.
- Is financially literate and financially responsible at home and in the broader community.
- Is knowledgeable about careers and can plan, execute, and alter career goals in response to changing societal and economic conditions.
- Seeks to attain skill and content mastery to achieve success in a chosen career path.

Career Ready Practices

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

CRP1. Act as a responsible and contributing citizen and employee.

Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

CRP2. Apply appropriate academic and technical skills.

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.

CRP3. Attend to personal health and financial well-being.

Career-ready individuals understand the relationship between personal health, workplace performance and personal well-being; they act on that understanding to regularly practice healthy diet, exercise and mental health activities. Career-ready individuals also take regular action to contribute to their personal financial wellbeing, understanding that personal financial security provides the peace of mind required to contribute more fully to their own career success.

CRP4. Communicate clearly and effectively and with reason.

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

CRP5. Consider the environmental, social and economic impacts of decisions.

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

CRP6. Demonstrate creativity and innovation.

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

CRP7. Employ valid and reliable research strategies.

Career-ready individuals are discerning in accepting and using new information to make decisions, changes. They use reliable research process to search for new information. They evaluate the validity of sources when considering the use and adoption of external information or practices in their workplace situation.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

CRP9. Model integrity, ethical leadership and effective management.

Career-ready individuals consistently act in ways that align personal and community-held ideals and principles while employing strategies to positively influence others in the workplace. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the directions and actions of a team or organization, and they apply insights into human behavior to change others' action, attitudes and/or beliefs. They recognize the near-term and long-term effects that management's actions and attitudes can have on productivity, morals and organizational culture.

CRP10. Plan education and career paths aligned to personal goals.

Career-ready individuals take personal ownership of their own education and career goals, and they regularly act on a plan to attain these goals. They understand their own career interests, preferences, goals, and requirements. They have perspective regarding the pathways available to them and the time, effort, experience and other requirements to pursue each, including a path of entrepreneurship. They recognize the value of each step in the education and experiential process, and they recognize that nearly all career paths require ongoing education and experience. They seek counselors, mentors, and other experts to assist in the planning and execution of career and personal goals.

CRP11. Use technology to enhance productivity.

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

CRP12. Work productively in teams while using cultural global competence.

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

2014 New Jersey Core Curriculum Content Standards - Technology

Content Area	**Technology**		
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**		
Strand	**A. Technology Operations and Concepts:** *Students demonstrate a sound understanding of technology concepts, systems and operations.*		
Grade Level bands	**Content Statement Students will:**	**Indicator**	**Indicator**
P	Understand and use technology systems.	8.1.P.A.1	Use an input device to select an item and navigate the screen
		8.1.P.A.2	Navigate the basic functions of a browser.
	Select and use applications effectively and productively.	8.1.P.A.3	Use digital devices to create stories with pictures, numbers, letters and words.
		8.1.P.A.4	Use basic technology terms in the proper context in conversation with peers and teachers (e.g., camera, tablet, Internet, mouse, keyboard, and printer).
		8.1.P.A.5	Demonstrate the ability to access and use resources on a computing device.
K-2	Understand and use technology systems.	8.1.2.A.1	Identify the basic features of a digital device and explain its purpose.
	Select and use applications effectively and productively.	8.1.2.A.2	Create a document using a word processing application.
		8.1.2.A.3	Compare the common uses of at least two different digital applications and identify the advantages and disadvantages of using each.
		8.1.2.A.4	Demonstrate developmentally appropriate navigation skills in virtual environments (i.e. games, museums).
		8.1.2.A.5	Enter information into a spreadsheet and sort the information.
		8.1.2.A.6	Identify the structure and components of a database.
		8.1.2.A.7	Enter information into a database or spreadsheet and filter the information.
3-5	Understand and use technology systems.	8.1.5.A.1	Select and use the appropriate digital tools and resources to accomplish a variety of tasks including solving problems.
	Select and use applications effectively	8.1.5.A.2	Format a document using a word processing application to enhance text

	and productively.		and include graphics, symbols and/ or pictures.
		8.1.5.A.3	Use a graphic organizer to organize information about problem or issue.
		8.1.5.A.4	Graph data using a spreadsheet, analyze and produce a report that explains the analysis of the data.
		8.1.5.A.5	Create and use a database to answer basic questions.
		8.1.5.A.6	Export data from a database into a spreadsheet; analyze and produce a report that explains the analysis of the data.
6-8	Understand and use technology systems.	8.1.8.A.1	Demonstrate knowledge of a real world problem using digital tools.
	Select and use applications effectively and productively.	8.1.8.A.2	Create a document (e.g. newsletter, reports, personalized learning plan, business letters or flyers) using one or more digital applications to be critiqued by professionals for usability.
		8.1.8.A.3	Use and/or develop a simulation that provides an environment to solve a real world problem or theory.
		8.1.8.A.4	Graph and calculate data within a spreadsheet and present a summary of the results
		8.1.8.A.5	Create a database query, sort and create a report and describe the process, and explain the report results.
9-12	Understand and use technology systems.	8.1.12.A.1	Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.
	Select and use applications effectively and productively.	8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
		8.1.12.A.3	Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.
		8.1.12.A.4	Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
		8.1.12.A.5	Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Content Area	**Technology**
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**
Strand	**B. Creativity and Innovation:** *Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.*

Grade Level bands	Content Statement Students will:	Indicator	Indicator
P	Apply existing knowledge to generate new ideas, products, or processes. Create original works as a means of personal or group expression.	8.1.P.B.1	Create a story about a picture taken by the student on a digital camera or mobile device.
K-2		8.1.2.B.1	Illustrate and communicate original ideas and stories using multiple digital tools and resources.
3-5		8.1.5.B.1	Collaborative to produce a digital story about a significant local event or issue based on first-person interviews.
6-8		8.1.8.B.1	Synthesize and publish information about a local or global issue or event (ex. telecollaborative project, blog, school web).
9-12		8.1.12.B.2	Apply previous content knowledge by creating and piloting a digital learning game or tutorial.

Content Area	**Technology**
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**
Strand	**C. Communication and Collaboration:** *Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.*

Grade Level bands	**Content Statement**	**Indicator**	**Indicator**
P	Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media. Communicate information and ideas to multiple audiences using a variety of media and formats. Develop cultural understanding and global awareness by engaging with learners of other cultures. Contribute to project teams to produce original works or solve problems.	8.1.P.C.1	Collaborate with peers by participating in interactive digital games or activities.
K-2		8.1.2.C.1	Engage in a variety of developmentally appropriate learning activities with students in other classes, schools, or countries using various media formats such as online collaborative tools, and social media.
3-5		8.1.5.C.1	Engage in online discussions with learners of other cultures to investigate a worldwide issue from multiple perspectives and sources, evaluate findings and present possible solutions, using digital tools and online resources for all steps.
6-8		8.1.8.C.1	Collaborate to develop and publish work that provides perspectives on a global problem for discussions with learners from other countries.
9-12		8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

Content Area	**Technology**		
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**		
Strand	**D. Digital Citizenship:** *Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.*		
Grade Level bands	**Content Statement**	**Indicator**	**Indicator**
K-2	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.2.D.1	Develop an understanding of ownership of print and nonprint information.
3-5	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.5.D.1	Understand the need for and use of copyrights.
		8.1.5.D.2	Analyze the resource citations in online materials for proper use.
	Demonstrate personal responsibility for lifelong learning.	8.1.5.D.3	Demonstrate an understanding of the need to practice cyber safety, cyber security, and cyber ethics when using technologies and social media.
	Exhibit leadership for digital citizenship.	8.1.5.D.4	Understand digital citizenship and demonstrate an understanding of the personal consequences of inappropriate use of technology and social media.
6-8	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.8.D.1	Understand and model appropriate online behaviors related to cyber safety, cyber bullying, cyber security, and cyber ethics including appropriate use of social media.
	Demonstrate personal responsibility for lifelong learning.	8.1.8.D.2	Demonstrate the application of appropriate citations to digital content.
		8.1.8.D.3	Demonstrate an understanding of fair use and Creative Commons to intellectual property.
	Exhibit leadership for digital citizenship.	8.1.8.D.4	Assess the credibility and accuracy of digital content.
		8.1.8.D.5	Understand appropriate uses for social media and the negative consequences of misuse.
9-12	Advocate and practice safe, legal, and responsible use of information and technology.	8.1.12.D.1	Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.
	Demonstrate personal responsibility for	8.1.12.D.2	Evaluate consequences of unauthorized electronic access (e.g., hacking)

	lifelong learning.		and disclosure, and on dissemination of personal information.
		8.1.12.D.3	Compare and contrast policies on filtering and censorship both locally and globally.
	Exhibit leadership for digital citizenship.	8.1.12.D.4	Research and understand the positive and negative impact of one's digital footprint.
		8.1.12.D.5	Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs.

Content Area	**Technology**
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**
Strand	**E: Research and Information Fluency:** *Students apply digital tools to gather, evaluate, and use information.*

Grade Level bands	**Content Statement** **Students will:**	**Indicator**	**Indicator**
P	Plan strategies to guide inquiry.	8.1.P.E.1	Use the Internet to explore and investigate questions with a teacher's support.
K-2	Plan strategies to guide inquiry Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.	8.1.2.E.1	Use digital tools and online resources to explore a problem or issue.
3-5	Plan strategies to guide inquiry. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.	8.1.5.E.1	Use digital tools to research and evaluate the accuracy of, relevance to, and appropriateness of using print and non-print electronic information sources to complete a variety of tasks.

6-8	Plan strategies to guide inquiry. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. Evaluate and select information sources and digital tools based on the appropriateness for specific tasks. Process data and report results.	8.1.8.E.1	Effectively use a variety of search tools and filters in professional public databases to find information to solve a real world problem.
9-12	Plan strategies to guide inquiry. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. Evaluate and select information sources and digital tools based on the appropriateness for specific tasks. Process data and report results.	8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
		8.1.12.E.2	Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.

Content Area	**Technology**
Standard	**8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.**
Strand	**F: Critical thinking, problem solving, and decision making:** *Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.*

Grade Level bands	**Content Statement Students will:**	**Indicator**	**Indicator**
K-2	Identify and define authentic problems and significant questions for investigation. Plan and manage activities to develop a solution or complete a project.	8.1.2.F.1	Use geographic mapping tools to plan and solve problems.

	Collect and analyze data to identify solutions and/or make informed decisions. Use multiple processes and diverse perspectives to explore alternative solutions.		
3-5	Identify and define authentic problems and significant questions for investigation. Plan and manage activities to develop a solution or complete a project. Collect and analyze data to identify solutions and/or make informed decisions. Use multiple processes and diverse perspectives to explore alternative solutions	8.1.5.F.1	Apply digital tools to collect, organize, and analyze data that support a scientific finding.
6-8	Identify and define authentic problems and significant questions for investigation. Plan and manage activities to develop a solution or complete a project. Collect and analyze data to identify solutions and/or make informed decisions. Use multiple processes and diverse perspectives to explore alternative solutions.	8.1.8.F.1	Explore a local issue, by using digital tools to collect and analyze data to identify a solution and make an informed decision.
9-12	Identify and define authentic problems and significant questions for investigation. Plan and manage activities to develop a solution or complete a project.	8.1.12.F.1	Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

	Collect and analyze data to identify solutions and/or make informed decisions. Use multiple processes and diverse perspectives to explore alternative solutions.		