AP Physics I

Curriculum

Board Approved:

Francis Howell School District

Mission Statement

Francis Howell School District is a learning community where all students reach their full potential.

Vision Statement

Francis Howell School District is an educational leader that builds excellence through a collaborative culture that values students, parents, employees, and the community as partners in learning.

Values

Francis Howell School District is committed to:

- Providing a consistent and comprehensive education that fosters high levels of academic achievement for all
- Operating safe and well-maintained schools
- Promoting parent, community, student, and business involvement in support of the school district
- Ensuring fiscal responsibility
- Developing character and leadership

Francis Howell School District Graduate Goals

Upon completion of their academic study in the Francis Howell School District, students will be able to:

1. Gather, analyze and apply information and ideas.
2. Communicate effectively within and beyond the classroom.
3. Recognize and solve problems.
4. Make decisions and act as responsible members of society.

AP Physics I Graduate Goals

The students in the Francis Howell School District will graduate with the knowledge, skills, and attitudes essential to leading a productive, meaningful life.

Graduates will:

- Understand and apply principles of scientific investigation.
- Utilize the key concepts and principles of life, earth, and physical science to solve problems.
- Recognize that science is an ongoing human endeavor that helps us understand our world.
- Realize that science, mathematics, and technology are interdependent, each with strengths and limitations impacting the environment and society.
- Use scientific knowledge and scientific ways of thinking for individual and social purposes.

Course Rationale

Science education develops science literacy. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. Scientific literacy has become a necessity for everyone.

To accomplish this literacy, science courses will reflect the following:

- Develop scientific reasoning and critical thinking skills.
- Extend problem-solving skills using scientific methods.
- Include lab-based experiences.
- Strengthen positive attitudes about science.
- Incorporate the use of new technologies.
- Provide relevant connections to personal and societal issues and events.

Course Description

AP Physics 1 is an algebra-based, introductory college-level physics course that explores topics such as Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; and introductory, simple circuits. Through inquiry- based learning, students will develop scientific critical thinking and reasoning skills. The student should have solid algebra skills and have been introduced to trigonometry. This course requires a high degree of independent initiative. This is a preparatory course for the AP Physics 1 exam. Advanced credit, when available.

Curriculum Committee

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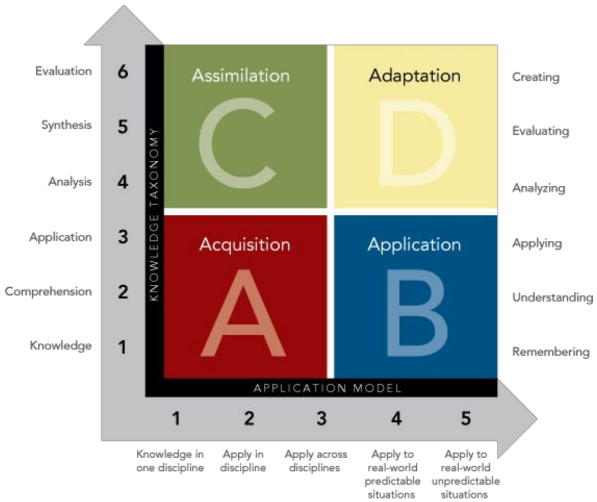
Curriculum Notes

All FHSD performance tasks and sample learning activities are aligned not only to understandings and standards, but also the Rigor and Relevance Framework and 21st Century Skills. Information on these two things is provided below or by clicking on the hyperlinks.



Rigor and Relevance Framework

The Rigor/Relevance Framework is a tool developed by the International Center to examine curriculum, instruction, and assessment along the two dimensions of higher standards and student achievement.

The Rigor/Relevance Framework has four quadrants.
Quadrant A represents simple recall and basic understanding of knowledge for its own sake. Examples of Quadrant A knowledge are knowing that the world is round and that Shakespeare wrote Hamlet.

A	B	C	D
Students gather and store bits of knowledge and information. Students are primarily expected to remember or understand this knowledge.	Students use acquired knowledge to solve problems, design solutions, and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.	Students extend and refine their acquired knowledge to be able to use that knowledge automatically and routinely to analyze and solve problems and create solutions.	Students have the competence to think in complex ways.

Quadrant C represents more complex thinking but still knowledge for its own sake. Quadrant C embraces higher levels of knowledge, such as knowing how the U.S. political system works and analyzing the benefits and challenges of the cultural diversity of this nation versus other nations.

Quadrants B and D represent action or high degrees of application. Quadrant B would include knowing how to use math skills to make purchases and count change. The ability to access information in wide-area network systems and the ability to gather knowledge from a variety of sources to solve a complex problem in the workplace are types of Quadrant D knowledge.

21st Century Skills

These skills have been pared down from 18 skills to what are now called the 4Cs. The components include critical thinking, communication, collaboration, and creativity. Critical thinking is focused, careful analysis of something to better understand and includes skills such as arguing, classifying, comparing, and problem solving. Communication is the process of transferring a thought from one mind to others and receiving thoughts back and includes skills such as choosing a medium (and/or technology tool), speaking, listening, reading, writing, evaluating messages. Collaboration is working together with others to achieve a common goal and includes skills such as delegating, goal setting, resolving conflicts, team building, decision-making, and managing time. Creativity is expansive, open-ended invention and discovery of possibilities and includes skills such as brainstorming, creating, designing, imagining, improvising, and problem-solving.

Standards

Standards aligned to this course can be found:

AP Physics Standards
http://media.collegeboard.com/digitalServices/pdf/ap/ap-physics-course-description.pdf

Missouri Learning State Standards for Literacy
http://www.corestandards.org/ELA-Literacy/

National Educational Technology Standards
http://www.iste.org/STANDARDS

Units & Standards Overview
Semester 1 Semester 2

Unit 1: 8 weeks	**Unit 2:** 5 weeks	**Unit 3:** 5 weeks	**Unit 4:** 4 weeks
Kinematics in One and Two Dimensions	Dynamics	Energy and Conservation of Energy	Impulse, Momentum, and Conservation of Momentum
PE Assessment: 3.A.1.1, 3.A.1.3, 4.A.1.1, 4.A.2.1 4.A.2.3, RST.1, RST.2, RST.4 WHST.1	PE Assessment: 1.C.1.1, 2.B.1.1, 3.A.2.1, 3.A.3.1, 3.A.3.2, 3.A.4.1, 3.B.1.1, 3.B.1.3, 4.A.3.1 RST.1, RST.2, RST.6, RST.8, WHST.1, WHST.2	PE Assessment: 3.E.1.1, 3.E.1.4, 4.C.1.2 4.C.2.1, 4.C.2.2, 5.A.2.1 5.B.4.1, 5.B.1.2, 5.B.4.1 5.B.5.1, 5.B.5.3, RST.2, RST.4, RST.5, RST.6, RST.7 WHST.1	PE Assessment: 3.D.1.1, 3.D.2.1, 3.D.2.2 3.D.2.3, 4.B.1.1, 4.B.1.2 4.B.2.2, 5.A.2.1, 5.D.1.1 5.D.2.4, 5.D.3.1, RST.2, RST.4, RST.6, RST.7, RST.8, WHST.1
Kinematics in 1 and 2 D	Dynamics	Energy	Momentum

Unit 5: 3 weeks	**Unit 6:** 4 weeks	**Unit 7:** 2 weeks	**Unit 8:**2 week
Circular Motion and Gravitation	Rotational Motion and Conservation of Angular Momentum	Simple Harmonic Motion, Mechanical Waves and Sound	Electrostatics and DC Circuits
PE Assessment: 1.C.3.1, 2.B.1.1, 2.B.2.1 2.B.2.2, 3.C.1.1, 3.C.1.2 RST.2, RST.4, RST.8 RST.10, WHST.1, WHST.2 WHST.4	PE Assessment: 3.F.1.1, 3.F.1.2, 3.F.1.3 3.F.1.5, 3.F.2.1, 3.F.3.2 4.D.2.1, 5.A.2.1 5.E.1.2, ISTE.3, RST.1 RST.2, RST.7, WHST. 2, WHST.4	PE Assessment: 1.B.1.2, 1.B.2.1, 3.C.2.1 3.C.2.2, 5.A.2.1, 5.B.9.1 5.C.3.1, 5.C.3.2, 5.C.3.1 ISTE.4, RST.2, RST.4 RST.8, RST.10 WHST.1, WHST.2, WHST.4	PE Assessment: 3.B.3.1, 3.B.3.2, 3.B.3.4, 1.B.1.1 5.B.2.1, 6.A.1.1, 6.A.2.1, 1.B.1.2 6.A.4.1, 6.D.1.1, 6.D.3.3, 1.B.2.1 6.D.4.2, 6.D.5.1, ISTE. 3 ISTE.4, RST.1, RST.2 RST.3, RST.4, WHST.1, WHST.2
Circular Motion and Gravitation Performance Task	Rotational Motion Performance Task	Waves and Simple Harmonic Motion Performance Task	Electrostatics and DC Circuits Performance Task

Course Map: Semester 1

Unit 1: Kinematics in One and Two Dimensions	**Unit 2: Statics and Dynamics**	**Unit 3: Energy and Conservation of Energy**	**Unit 4: Impulse, Momentum and Conservation of Momentum**
• distinguish between position distance and displacement • meaning behind the slope of a x/t and v/t graphs • meaning of area under a v/t graph • Position, Velocity and Acceleration can be represented by a vector • Development of the three kinematic equations • Use y=mx+b to describe the relationship between variables on a linear graph • linearize a graph • Separate the motion of an object into dimensions connected by time • acceleration must be a constant to use the kinematic equations kinematic equations **3.A.1.1** RST.1 ISTE.1 3.A.1.2 RST.2 ISTE.2 **3.A.1.3** RST.3 ISTE.3 **4.A.1.1** RST.4 ISTE.4 **4.A.2.1** RST.7-.9 4.A.2.2 WHST.1-.4 **4.A.2.3** WHST.7-.8	• force diagrams • recognize the types of forces and their causes • Vectorial addition of forces • develop idea of a system • internal vs external forces • external forces cause acceleration • internal forces are cancelled • Force mass and acceleration connection • quantify friction, gravitational, and elastic forces **1.C.1.1** **3.B.1.1** RST.1-.4 **3.A.2.1** 3.B.1.2 RST.6-.8 **3.A.3.1** **3.B.1.3** **3.A.3.2** 3.B.2.1 WHST.1-.4 **3.A.3.3** 3.C.4.1 WHST.6-.8 3.A.3.4 3.C.4.2 **3.A.4.1** **4.A.3.1** ISTE.1-.4 3.A.4.2 4.A.3.2 3.A.4.3 **4.A.3.1**	• recognize when energy is transferred/transformed, depending on the choice of the system • tracking energy changes with pie and bar charts, that leads to equations • quantify work, elastic, kinetic, gravitational energy • meaning of area under a f/d grap **3.E.1.1** 5.B.3.3 RST.1-.8 **5.B.5.1** **5.B.4.1** 3.E.1.2 5.B.4.2 WHST.1 3.E.1.3 **5.B.5.2** WHST.3-.5 **3.E.1.4** 5.B.5.3 WHST.8 4.C.1.1 5.B.5.4 **4.C.1.2** 5.B.5.5 **4.C.2.1** **5.B.5.1** **4.C.2.2** **5.A.2.1** ISTE.1-.4 5.B.1.1 ISTE.6 **5.B.1.2** 5.B.3.1 5.B.3.2	• elastic collisions, inelastic collisions, and explosions all conserve momentum • only elastic collisions conserve energy • momentum is a vector • external forces cause a change in momentum • impulse and newtons 2nd law are connected • meaning area of a f/t graph **3.D.1.1** 5.D.2.1 **3.D.2.1** 5.D.2.2 **3.D.2.2** 5.D.2.3 **3.D.2.3** **5.D.2.4** 3.D.2.4 **5.D.3.1** **4.B.1.1** **4.B.1.2** RST.1-RST.4 4.B.2.1 RST.6-RST.9 **4.B.2.2** **5.A.2.1** WHST.1-WHST.2 **5.D.1.1** WHST.5 5.D.1.2 WHST.7-WHST.8 5.D.1.3 5.D.1.4 ISTE.1-ISTE.4 5.D.1.5

Course Map: Semester 2

Unit 5: Circular Motion and Gravitation

- connection between linear motion and UCM
- Force is always perpendicular to motion
- Centripetal force can be any force, or component of a force that points toward the center
- quantify the velocity of an object in UCM
- quantify the centripetal force
- orbits form because the Fc is Gravity

1.C.3.1 RST.1-.4
2.B.1.1 RST.6-.8
2.B.2.1 RST.10
2.B.2.2
3.A.2.1
3.A.3.1
3.A.3.3
3.B.1.2 ISTE.2-.4
3.B.1.3
3.B.2.1
3.C.1.1 WHST.1-.2
3.C.1.2 WHST.4
WHST.8-.9

Unit 6: Rotational Motion and Conservation of Angular Momentum

- relate torque with moment of inertia and angular acceleration
- rotational motion has analogs with linear motion
- quantify the moment of inertia for simple shaped objects

3.F.1.1 **5.A.2.1**
3.F.1.2 5.E.1.1
3.F.1.3 **5.E.1.2**
3.F.1.4 5.E.2.1
3.F.1.5 **4.D.1.1**
3.F.2.1
3.F.2.2
3.F.3.1 RST.1-.8
3.F.3.2
3.F.3.3 WHST.1-.4
4.D.2.1
4.D.2.2 ISTE.1-.4
4.D.3.1
4.D.3.2

Unit 7: Simple Harmonic Motion, Mechanical Waves and Sound

- the period of a SHM is independent of amplitude
- the restoring force is proportional to displacement from equilibrium
- quantify the period of a spring and pendulum
- recognize various positions of SHM in terms of F, a, and Energy

3.B.3.1 6.D.3.1 - **6.D.3.3**
3.B.3.2 6.D.4.1 6.D.3.4
3.B.3.3 **6.D.4.2**
3.B.3.4 **6.D.5.1**
5.B.2.1
6.A.1.1 RST.1-RST.4
6.A.1.2
6.A.2.1 RST.7-RST.8
6.A.3.1
6.A.4.1 WHST.1-.2
6.B.1.1 WHST.7
6.B.2.1
6.B.4.1 ISTE.1-ISTE.4
6.B.5.1
6.D.1.1
6.D.2.1

Unit 8: Electrostatics and DC Circuits

- Recognize that two types of charges exist
- Charges are able to move and interact
- Quantify electric forces using Coulomb's law
- Draw force diagrams showing how charges interact
- Connect concepts of electric field to gravitational field
- Working circuit consist of
- Ohm's Law
- What is power and how does it relate to light bulbs and household appliances
- determine how an ohmic device differs from a non-ohmic device
- Determine the resistance difference between parallel and series circuits
- Measure the voltage & current in parallel & series circuits

1.B.1.1-1.2, 1B.2.1, 1.B.3.1 **3.C.2.1-2.2**, **5.A.2.1**, **5.B.9.1**-.3 **5.C.3.1-.3**, ISTE.1-.4, RST.1-.2, RST.4, RST.7-.8, RST.10, WHST.1-.2, WHST.4, WHST.7-.8

Content Area: Science	Course: AP Physics 1	UNIT 1: Kinematics in One and Two Dimensions

Unit Description:	Unit Timeline:
Kinematics is the study of motion and how position, velocity and acceleration are related	Approx 8 weeks.

DESIRED Results
<u>Transfer Goal</u> - ***Students will be able to independently use their learning to……*** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>Understandings</u> – *Students will understand that… (Big Ideas)*

1. The motion of an object can be described using narrative, mathematical, and graphical representations.
2. The Kinematic Equations relate the Position, and Velocity of an object to its Acceleration.
3. An experiment can be designed to investigate the motion of an object.
4. Velocity can be expressed as a vector and acceleration is the rate of change of velocity over time.

<u>Essential Questions</u>: Students will keep considering…

- How can the motion of an object moving at constant velocity be described and represented?
- How can the motion of an object that is accelerating be described and represented?
- What information can be gathered from the motion of graphs?
- What are the characteristics of the motion of a projectile launched at an angle?
- How can an experiment be used to describe the motion of a constantly accelerating object?

Students will know…..	Standard		Students Will Be Able to…..	Standard
An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.What facts and basic concepts should students know and be able to recall? The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass. The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.	*3.A.1* *4.A.1* *4.A.2*		The student is able to express the motion of an object using narrative, mathematical, and graphical representations. The student is able to design an experimental investigation of the motion of an object. 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. 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 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. 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. 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.	***3.A.1.1*** *3.A.1.2* ***3.A.1.3*** ***4.A.1.1*** ***4.A.2.1*** *4.A.2.2* ***4.A.2.3***

			<u>Common Core Reading Standards for Grades 11 - 12</u>	
			Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	RST.1
			Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	RST.2
			Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	RST.3
			Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics.*	RST.4
			Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	RST. 7
			Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	RST.8
			Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	RST.9

			<u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on *discipline-specific content*. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas,	WHST.1 WHST.2

			concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	 WHST.4 WHST.7

			Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities 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. a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems Research and information fluency. Students apply digital tools to gather, evaluate,	WHST.8 ISTE.1 ISTE.2 ISTE.3

			and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	ISTE.4

EVIDENCE of LEARNING

Understanding	Standards	Unit Performance Assessment:	R/R Quadrant
1,2,3,4	3.**A.1.1** **3.A.1.3** **4.A.1.1** **4.A.2.1** **4.A.2.3** RST.1 RST.2 RST.4 WHST.1	**Description of Assessment Performance Task(s):** Students will analyze, assess, and predict outcomes of various objects in different scenarios of motion. A sprinters 100 meter dash run will be analyzed for acceleration and velocity during the race. See Appendix - 1.A unit 1 - Kinematics in 1 and 2 D Performance Task. **Teacher will assess:** 1) The student's ability to correctly determine the components of projectile motion and two dimensional motion to solve problems. 2) The student's ability to analyze one dimensional motion and the interaction of velocity and acceleration. 3) The correct use of position vs time graph to determine velocity and acceleration. 4) Correctly determining the velocity, acceleration, and time for the 100 meter dash. **Performance:** **Mastery:** *Students will show that they really understand when they…* 1. Receive an 80% or better on the Performance Task. **Scoring Guide:** *See Appendix __1.C Unit 1 - Kinematics assessment blueprint template and 1.B Unit 1 - Kinematics Performance Task Rubric*	*C* **21 Century** Critical Thinking

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 1 - 01 Unit 1 - Kinematics Pre-Assessment. Includes answer key.

Understanding	**Standards**	**Major Learning Activities: Activities are designed to prepare students for AP Test items.**	**Instructional Strategy:**	**R/R Quadrant:** **21 Century**
1, 2, 3	3.A.1.1 3.A.1.2 3.A.1.3 4.A.1.1 ISTE.1 WHST.1 RST.1 RST.2	1. Activity: Buggy Car Lab ● In pairs (Mix-Pair-Share), students develop a way to predict where two battery-powered cars will collide if they are released from opposite ends of the lab table at different times. Students collect data and then make and test their predictions. Students will have an opportunity to write a persuasive argument based on predictions. ● Objective: Students, in their lab journals, will be able to include multiple representations of their investigation that validate their predictions about collisions. These include verbal descriptions, motion diagrams, graphical analyses, and equations. appendix:1.D-Buggy Car Lab	Cooperative learning Generating and Testing Hypotheses	C Communication Creativity
1	3.A.1.1 3.A.1.2 3.A.1.3 4.A.2.1 4A.2.2 ISTE.2 RST.3	2. Activity: Graph Matching ● Students work in teams of three or four to determine the proper placement of an air track, a glider, and a motion detector to produce a motion that matches a set of given graphs: position versus time, velocity versus time, and acceleration versus time. ● Objective: Students will be able to understand graphs and the relationships of position, velocity, and acceleration. appendix: 1.E-Graph Matching	Nonlinguistic representation	A Critical Thinking
2, 3	3.A.1.1 3.A.1.2 3.A.1.3 4.A.2.3	3. Activity: Free-Fall Investigation ● Students working in teams of three or four (Pairs Compare) design and implement an experiment to determine and compare the acceleration of two objects that are dropped simultaneously.	Generating and testing hypotheses	D Creativity

	ISTE.2 ISTE.3 RST.1 RST.9 WHST.2 WHST.7	Groups will have the opportunity to peer evaluate other groups experimental designs and data then provide feedback and formally reflect on outcome ● Objective: Students will be able to determine acceleration principle of falling objects. appendix: 1.F-Freefall		
3, 4	3.A.2.1 4.A.2.2 RST.8 WHST.4	4. Activity: Force Table ● Students work in teams of three to design and implement an investigation in which they use a force table set to determine the value of a resultant of several vectors, and then compare that value to the values obtained through graphical and analytical methods. Students whiteboard results to present to the rest of the class. ● Objective: Students will demonstrate their ability to do force vector analysis and design experiments. appendix: 1.G-Force Table	Cooperative Learning	B Collaboration
2, 3, 4	3.A.1.1 3.A.1.2 3.A.1.3 4.A.1.1 4.A.2.2 WHST.1 WHST.4 WHST.7 WHST.8	5. Activity: Horizontal Launch vs. Drop ● This teacher-led demonstration illustrates the independence of horizontal and vertical components of motion. Using an attachment to the projectile launcher that simultaneously drops one ball while giving the other a horizontal velocity. The students determine which ball will hit the floor first. This demo works better when the balls hit a hard surface so that there is a simultaneous sound as the balls hit the floor. ● Objective: Students will understand how two dimensional motion interacts in projectile motion compared to one dimensional. appendix: 1.H-Horizontal Launch vs Drop	Identifying similarities and differences	B Critical Thinking
1, 3, 4	3.A.1.1 3.A.1.2 3.A.1.3 RST.6 ISTE.4 WHST.4 WHST.8	6. Activity: Hunter and the Monkey ● Given a projectile launcher, a projectile, and a meterstick, students design an experiment to determine the initial velocity of a projectile and the angle at which a projectile can be used to hit a dropped target. As a challenge, the students are asked to predict where the projectile will land and make a formal argument supporting the prediction.	Cues, questions, advance organizers	C Creativity

		• Objective: Students will understand and be able to demonstrate principles of projectile motion appendix: 1.I-Hunter and the Monkey		

UNIT RESOURCES
Teacher Resources: • Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. • College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. • Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim • https://secure-pgp.wikispaces.com/home • http://apphysicslinks.weebly.com/teaching-ap-physics.html • http://www.wikipremed.com/01physicscards.php?card=2 • https://sites.google.com/site/apphysicsinquiry/home • https://www.youtube.com/user/bohacekphysics/videos • http://modelinginstruction.org/ • http://www.islephysics.net/ • http://dev.physicslab.org/Default.aspx • http://ninenet.pbslearningmedia.org/collection/npe11/ • http://noschese180.wordpress.com/ • http://www.learner.org/courses/physics/index.html
Student Resources: • Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. • College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. • https://phet.colorado.edu/en/simulations/category/physics • http://hypertextbook.com/ • https://prettygoodphysics.wikispaces.com/home • http://www.learnapphysics.com/ • https://www.youtube.com/user/bohacekphysics/videos • http://www.physicsclassroom.com/ • http://dev.physicslab.org/Default.aspx • http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Kinematics – study of how objects move and describing the motion mathematically.
Dynamics – study of forces and why objects move as they do.
Translational motion – objects that move without rotating during movement.
Displacement – how far an object is from its starting point.
Vector – quantity that has both magnitude and direction.
Scalar – quantity that only has magnitude.
Speed – how far an object travels in a given time interval regardless of direction.
Velocity – how fast an object is moving and in which direction it is moving.
Acceleration – the change in velocity per unit time.
Free fall – all objects fall with the same constant acceleration in the absence of air or other resistance.
Projectile motion – translational motion of objects moving through the air in two dimensions.

Content Area: Science	Course: AP Physics 1	UNIT 2: Statics and Dynamics

Unit Description: The cause of motion is a result of the combination of forces acting on an object with mass.	Unit Timeline: Approx. 5 Weeks

DESIRED Results
<u>Transfer Goal</u> - **Students will be able to independently use their learning to……** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>Understandings</u> **– Students will understand that… (Big Ideas)**

1. Changes in the net force on an object, or its inertial mass, will affect its acceleration.
2. Gravitational mass is measured statically and inertial mass is measured dynamically.
3. Forces are interactions between two objects and can be represented by vectors and can be added together in a free body diagram.
4. Forces can be considered as contact forces or field forces.

<u>Essential Questions</u>**: Students will keep considering…**

- How can the forces on an object be represented to determine the net force?
- How can a free-body diagram be used to create a mathematical representation of the forces acting on an object?
- How do Newton's Laws apply to interactions between objects at rest and in motion?
- How do Newton's Laws apply to systems of two or more objects?
- How is mass measured?

Students will know…..	Standard	Students Will Be Able to…..	Standard
Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems.	1.C.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.	**1.C.1.1**
Forces are described by vectors	3.A.2	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.	**3.A.2.1**
A force exerted on an object is always due to the interaction of that object with another object.	3.A.3		
If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite	3.A.4	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.	**3.A.3.1**
If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.direction.	3.B.1		
Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.	3.B.2	The student is able to challenge a claim that an object can exert a force on itself.	**3.A.3.2**
Contact forces result from the interaction of one object touching another object and they arise from interatomic electric forces. These forces include tension, friction, normal, and spring.	3.C.4	The student is able to describe a force as an interaction between two objects and identify both objects for any force.	**3.A.3.3**
		The student is able to make claims about the force on an object due to the presence of other objects with the same property: mass, electric charge.	3.A.3.4
Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center-of-mass velocity of that system.	4.A.3	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.	**3.A.4.1**
		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. 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. 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. 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. The student is able to re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces (interatomic electric forces). 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.	3.A.4.2 3.A.4.3 **3.B.1.1** 3.B.1.2 **3.B.1.3** 3.B.2.1 3.C.4.1 3.C.4.2

		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.	**4.A.3.1**
		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.	4.A.3.2
		<u>Common Core Reading Standards for Grades 11 - 12</u>	
		Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	RST.1
		Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	RST.2
		Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	RST.3
		Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.	RST.4
		Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	RST.6
		Integrate and evaluate multiple sources of information	RST.7

		presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	RST.8
		<u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of	WHST.1

		the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented.	
		Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).	WHST.2
		Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate the narrative elements effectively into arguments and information/explanatory texts. In science, students must be	WHST.3

		able to write precise descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results. Produce writing in which the organization, development, substance, and style are appropriate to task, purpose, and audience. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex	 WHST.4 WHST.6 WHST.7 WHST.8 ISTE.1

		systems and issues d. Identify trends and forecast possibilities 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. a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. e. Identify and define authentic problems and significant	ISTE.2 ISTE.3 ISTE.4

		questions for investigation f. Plan and manage activities to develop a solution or complete a project g. Collect and analyze data to identify solutions and/or make informed decisions h. Use multiple processes and diverse perspectives to explore alternative solutions	

EVIDENCE of LEARNING

Understanding	Standards	**Unit Performance Assessment**:	**R/R Quadrant**
1,3,4	**1.C.1.1** **3.A.2.1** **3.A.3.1** **3.A.3.2** **3.A.3.3** **3.A.4.1** 3.B.1.1 **3.B.1.3** **4.A.3.1** RST.1 RST.2 RST.6 RST.8 WHST.1	**Description of Assessment Performance Task(s):** Students will draw force diagrams showing how forces interact. Students will demonstrate their knowledge of Newton's Laws knowing how forces interact and if a system is accelerating. Hooke's Law will be demonstrated by determining the spring constant of a system. Vector analysis of objects moving on ramps will be conducted. Interaction of friction and the normal forces in a system will be analyzed. See Appendix - 2.A Unit 2 - Dynamics Performance Task. **Teacher will assess:** 1. Students ability to draw forces diagrams will be assessed. 2. Force interaction and Newton's Laws knowledge will be determined by analyzing force and acceleration scenarios. 3. Knowledge of Hooke's Law will be demonstrated by finding a spring constant and graphing the data to determine the slope. 4. Students will determine the interaction of friction, normal forces and vector analysis of objects on ramps. **Performance:** **Mastery:** Students will show that they really understand when they… achieve a 80% mastery on the performance task..	C **21 Century** Critical Thinking

	WHST.2	**Scoring Guide:** See Appendix ____2.C Unit 2 - Dynamic Assessment Blueprint Template and 2.B Unit 2 - Dynamic Performance Task Rubric	

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 2 - 02 Unit 2 - Dynamics Pre-Assessment. Includes answer key.

Understanding	**Standards**	**Major Learning Activities: Activities are designed to prepare students for AP Test items.**	**Instructional Strategy:**	**R/R Quadrant:** **21 Century**
1, 2	1.C.1.1 RST.1 WHST.4 ISTE.1 ISTE.3 ISTE.4	1. Activity: Inertial and Gravitational Mass Investigation ● Students working in pairs (Pairs Compare) design and implement an investigation to determine the difference (if any) between inertial mass and gravitational mass. ● Objective: Students will understand the difference between inertial and gravitational mass and how to measure them. appendix:2.D-Inertial and Gravitational Mass http://dev.physicslab.org/Document.atspx?doctype=3&filename=Dynamics_InertialGravitationalMass.xml	Identify similarities and differences	B Communication

3, 4	3.A.3.3 3.A.3.4 3.A.2.1 3.A.3.2 2.B.1.1 RST.1 RST.2 WHST.1 WHST.4	2. Activity: Forces Activity • The first part of this activity consists of an observational lab. The students work in pairs to create situations using a variety of materials (balls, books, carts, string) and learn to construct free-body diagrams for those situations. The students use whiteboards (Numbered Heads Together) to draw their free-body diagrams. The pairs take turns presenting their board to the rest of the class. Each pair displays their diagrams and briefly explains their thinking. I encourage the students to challenge each other's claims and support their answers with evidence (scientific formal argumentation). The second part of the lab includes a quantitative component, as the students calculate the value of the gravitational force on various objects. The students then determine the values of other forces, such as the normal force. • Objective: Students will understand and be able to draw free body diagrams while having an opportunity to write a persuasive description on why the forces in the free body diagrams are correct. appendix: 2.E-Forces	Summarizing and note taking	D Creativity Critical Thinking
1	3.A.3.1 3.A.3.3 3.A.3.4 3.A.2.1 3.B.1.2 3.B.2.1 ISTE.3 RST.1 WHST.2	3. Activity:Broom Ball Grand Prix • Students participate in a relay race by hitting a bowling ball with a broom through a clearly marked path. This activity allows students to focus on the kinesthetic experience of inertia. Students will demonstrate and explain the concept of inertia to an authentic audience in the context of physics. • Objective: Students will understand the concept of inertia and a force on an object is required to change direction or speed. Appendix: 2.F-Broom Ball Grand Prix http://www.slapt.org/resources/labs/bowlingprix.html	Cooperative learning	B Collaboration

3	3.A.3.1 3.A.3.3 3.A.2.1 ISTE.1 ISTE.2 ISTE.3 ISTE.4 RST.1 RST.2 RST.4 WHST.1 WHST.7	4. Activity: Inertia Demonstrations • Students work with a partner to conduct inertia demonstrations for the class. They are responsible for writing course specific claims about the activity using appropriate vocabulary. Each demonstration should include a clear, persuasive explanation of how Newton's first law applies. Examples are the tablecloth trick, the penny- on-a-hoop drop, the egg drop into a glass, pulling a dollar bill from between two bottles, sticking a straw through a potato, etc. • Objective: Students will demonstrate knowledge of Newton's First law developing different scenarios.. Appendix: 2.G- Inertia Demonstrations https://www.youtube.com/watch?v=T1ux9D7-O38	Cues, questions, and advance organizers	C Critical Thinking Creativity
3	3.A.3.1 3.A.3.3 3.A.2.1 3.B.1.2 3.B.2.1 ISTE.3 ISTE.4 RST.3 RST.6 WHST.8	5. Activity: Static Equilibrium Investigation • This activity is set up as demo with a dynamics cart that hangs balanced by strings. Students working in teams of three must determine the mass of the cart. They can read the tension in the strings from the spring scales and they can measure the angles of the strings. Their solution requires a free-body diagram and its corresponding mathematical expression in which teams offer formal arguments for their solutions. The teams then use a whiteboard to present their work to the class. The various teams compare their results and offer feedback to the teams that arrived at incorrect solutions. Students will have an opportunity to self-reflect at the conclusion of the activity. • Objective: Students will demonstrate their ability to conduct measurements for Newton's First Law and using vector analysis draw conclusions and present them to the class. Appendix: 2.H-Static Equilibrium Investigation http://dev.physicslab.org/Document.aspx?doctype=2&filename=Dynamics_StaticEquilibrium.xml	Setting objectives and providing feedback	B Creativity Critical Thinking Collaboration

1	3.A.3.3 3.A.3.1 3.A.2.1 3.B.1.1 3.B.1.2 3.B.1.3 3.B.2.1 ISTE.2 ISTE.4 RST.2 RST.8 WHST.1 WHST.6 WHST.7	6. Activity: Newton's Second Law Lab ● Students use a motion detector to determine the acceleration of a dynamics cart in two scenarios: (1) the total mass of the system is kept constant while the net force varies, and (2) the net force is kept constant while the total mass of the system varies. ● Objective: Students will evaluate data collected related to hypotheses and tests in order to support Newton's Second Law. They will reflect back on their hypothesis to determine if it was met along with why or why not. Appendix: 2.I-Newton's 2nd Law Lab http://dev.physicslab.org/Document.aspx?doctype=2&filename=Dynamics_PulleyCartSystem.xml	Generating and testing hypotheses	D Critical Thinking
1, 3	3.C.4.1 3.C.4.2 3.B.1.2 3.A.4.1 3.A.4.2 3.A.4.3 ISTE.2 ISTE.3 RST.1 RST.2 RST.4 RST.7 RST.8 WHST.1 WHST.3 WHST.4	7. Activity: Friction Lab ● Working in small groups, students design and implement two separate experiments to determine the maximum coefficient of static friction between a shoe and provided samples of linoleum and wood. In one experiment, the linoleum and wood samples are placed on a horizontal surface; in the other experiment, they are placed on an inclined plane. After completing the experiments, students find the percent difference between the two values of the coefficient of friction obtained for each surface. The post-lab discussion involves brief whiteboard presentations. Groups work in pairs, with one group presenting its results while the other group asks questions (Carousel Feedback). Then the groups switch roles. My role is to act as a facilitator and to ensure that the question- and-answer rounds run smoothly. ● Objective: Students will evaluate different surfaces for friction and present their conclusions to the class.	Reinforcing effort and providing recognition Cooperative learning	C Communication

		Appendix: 2.J-Friction Lab		
2	3.B.1.2 3.B.1.3 3.B.2.1 4.A.3.1 4.A.3.2 ISTE.2 ISTE.3 RST.2 RST.3 RST.4 RST.7 RST.8 WHST.1 WHST.3	8. Activity: Atwood's Machine Investigation ● Students work in small groups to construct an Atwood's machine or a modified Atwood's machine. They then design and implement an experiment to determine the acceleration of a hanging mass in the machine and the tension in the string. ● Objective: Students will demonstrate experimental design to prove Newton's Second Law. Appendix: 2.K-Atwood's Machine Investigation	Cooperative learning	B Collaboration

UNIT RESOURCES
Teacher Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim ● https://secure-pgp.wikispaces.com/home ● http://apphysicslinks.weebly.com/teaching-ap-physics.html ● http://www.wikipremed.com/01physicscards.php?card=2 ● https://sites.google.com/site/apphysicsinquiry/home ● https://www.youtube.com/user/bohacekphysics/videos ● http://modelinginstruction.org/ ● http://www.islephysics.net/

- http://dev.physicslab.org/Default.aspx
- http://ninenet.pbslearningmedia.org/collection/npe11/
- http://noschese180.wordpress.com/
- http://www.learner.org/courses/physics/index.html

Student Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- https://phet.colorado.edu/en/simulations/category/physics
- http://hypertextbook.com/
- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.
Force - any kind of push or pull on an object.
Newton's First Law of Motion – every object continues in its state of rest, or uniform velocity in a straight line, as long as no net force acts on it ($\Sigma F=0$).
Newton's Second Law of Motion – The acceleration of an object is directly proportional to the net force acting on it, and is inversely proportional to the object's mass. The direction of the acceleration is in the direction of the net force acting on it ($\Sigma F=ma$).
Newton's Third Law of Motion – whenever one object exerts a force on a second object, the second object exert an equal force in the opposite direction on the first.
Force – an action capable of accelerating an object.
Newton – a unit of force. One newton is the force required to impart an acceleration of 1 m/s^2 to a mass of 1 kg.
Normal Force – when a contact force acts perpendicular to the common surface of contact.
Weight – the magnitude of the force of gravity on an object.
Free-body Diagram – a diagram showing all the forces acting on each object involved.
Net Force – The vector sum of all forces acting on the object.
Friction - is the force resisting the relative motion of solid surfaces.
Kinetic Friction – the friction when objects are moving.
Static Friction – the friction when objects are stationary, tends to prevent motion.

Content Area: Science	Course: AP Physics 1	UNIT 3: Energy and Conservation of Energy

Unit Description:	Unit Timeline:
Energy is a conserved quantity that is transformed to different types in a system.	4 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

- Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

Understandings – ***Students will understand that… (Big Ideas)***

1. Mathematical reasoning can be used 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.
2. Mathematical reasoning can be used to create a description of the internal kinetic energy of a system from a description or diagram of the objects and interactions in that system.
3. Changes in the total energy of a system are due to changes in position and speed of objects or frictional interactions within the system and that total energy is conserved.

Essential Questions: ***Students will keep considering…***

- How are the different modes of energy storage transformed within a system and transformed between a system and the environment?
- How can energy be represented with graphs and equations?
- What does it mean for energy to be conserved?

Students will know…..	Standard	Students Will Be Able to…..	Standard
The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted. The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy. Mechanical energy (the sum of kinetic and potential energy) is transferred into or out of a system when an external force is exerted on a system such that a component of the force is parallel to its displacement. The process through which the energy is transferred is called work. For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings. Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects. A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces. The internal energy of a system includes the kinetic	3.E.1 4.C.1 4.C.2 5.A.2 5.B.1 5.B.3 5.B.4	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. 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. 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. 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. 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. 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. 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.	**3.E.1.1** 3.E.1.2 3.E.1.3 **3.E.1.4** 4.C.1.1 **4.C.1.2** **4.C.2.1**

energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.		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.	**4.C.2.2**
Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system.	5.B.5	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.	**5.A.2.1**
		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.	5.B.1.1
		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.	**5.B.1.2**
		The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.	5.B.3.1
		The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.	5.B.3.2
		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.	5.B.3.3
		The student is able to describe and make predictions about the internal energy of systems.	**5.B.4.1**

		The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.	5.B.4.2
		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.	**5.B.5.1**
		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.	**5.B.5.2**
		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.	5.B.5.3
		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).	5.B.5.4
		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.	5.B.5.5
		Common Core Reading Standards for Grades 11 - 12	
		Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or	RST.1

		inconsistencies in the account.	
		Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	RST.2
		Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	RST.3
		Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.	RST.4
		Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.	RST.5
		Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	RST.6
		Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	RST.7
		Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	RST.8
		Common Core Writing Standards for Grades 11-12	WHST.1

		Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented.	WHST.3
		Students' narrative skills continue to grow in these grades. The Standards require that students be ab le to incorporate the narrative elements effectively into arguments and information/explanatory texts. In science, students must be able to write precise descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.	WHST.4

		Produce writing in which the organization, development, substance, and style are appropriate to task, purpose, and audience. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities 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. a. Interact, collaborate, and publish with peers,	WHST.5 WHST.8 ISTE.1 ISTE.2

		experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	ISTE.3 ISTE.4 ISTE.6

		Technology operations and concepts. Students demonstrate a sound understanding of technology concepts, systems, and operations. a. Understand and use technology systems b. Select and use applications effectively and productively c. Troubleshoot systems and applications d. Transfer current knowledge to learning of new technologies	

EVIDENCE of LEARNING

<table>
<tr><td><u>Understanding</u>

1,2,3</td><td><u>Standards</u>

3.E.1.1
3.E.1.4
4.C.1.2
4.C.2.1
4.C.2.2
5.A.2.1
5.B.1.2
5.B.4.1
5.B.5.1
5.B.5.2
RST.2
RST.4
RST.5
RST.6
RST.7
WHST.1</td><td><u>Unit Performance</u> :
Description of Assessment Performance Task(s):
Students will develop a formula for speed of an oscillating object. Students will be able derive a formula for work done over time and be able to achieve the same information from a graph. Students will demonstrate principles of conservation of energy and the work - energy principle. Students will demonstrate the ability to calculate impulse.
See Appendix - 3.A Unit 3 - Energy Performance Task.

Teacher will assess:
What criteria will be used in each assessment to evaluate attainment of the desired results?
1. Students ability to use concepts of energy in simple harmonic motion of springs and pendulums.
2. Students understanding of Conservation of Energy and the Work - Energy Principle by being able to do calculations and develop formulas to use.
3. The ability to use impulse to calculate the amount of work done to catch baseball.
4. The ability to use force - displacement graph to determine the amount of to determine the amount of work accomplished.

<u>Performance:</u>
Mastery:
Students will show that they really understand when they…
achieve a 80% mastery on the performance task..

Scoring Guide:
See Appendix ______3.C Unit 3 - Energy Assessment Blueprint Template and 3.B Unit 3 - Energy Performance Task Rubric</td><td><u>R/R Quadrant</u>

C

<u>21 Century</u>

Critical Thinking</td></tr>
</table>

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 3 - 03 Unit 3 - Energy Pre-Assessment. Includes answer key.

Understanding	**Standards**	**Major Learning Activities: Activities are designed to prepare students for AP Test items.**	**Instructional Strategy:**	**R/R Quadrant:** **21 Century**
3	5.B.3.1 5.B.4.1 ISTE.1 ISTE.2 ISTE.4 RST.1 RST.7 RST.8 WHST.4	1. Activity: Where's the Money? ● Students are given a scenario in which they begin with a certain amount of money, and they study how that initial amount changes over time due to various deposits and purchases. They must balance the amount of money at different stages. (Find Someone Who) The activity takes about 20 minutes, and after they complete it we have a whole-class discussion to answer the question: "Where did the money go?" The goal is for the students to realize that even though they might not have cash, they have goods and savings at the bank. The activity allows for the introduction of important vocabulary for this unit: transference and transformation. ● Objective: Students will gain an understanding of how energy conservation works. Appendix: 3.D-Where's the Money?	Kagan Identifying similarities and differences	A Critical Thinking
1, 2, 3	5.B.3.1 5.B.3.2 5.B.3.3 4.C.1.1 4.C.1.2 5.B.1.1 5.B.1.2 5.B.4.1 5.B.4.2 ISTE.1	2. Activity: Roller Coaster Investigation ● Working in groups of three, students design a simple roller coaster using provided materials (a track with a vertical loop and toy cars) to test whether the total energy of a car–Earth system is conserved if there are no external forces exerted on it by other objects. Students include multiple representations of energy to provide evidence for their claims. They should use a bar chart, the mathematical expression of conservation of energy, and the corresponding calculations to evaluate and develop a formal argument whether the outcome of the experiment supports the idea of	Cues, questions, and advance organizers	B Collaboration Creativity

	ISTE.3 ISTE.4 RST.3 RST.7 WHST.3 WHST.8	energy conservation. • Objective: Students will gain an understanding of how kinetic and potential are conserved and can change from one form into another. Appendix: 3.E-Roller Coaster Investigation		
3	3.E.1.1 3.E.1.2 3.E.1.3 3.E.1.4 5.B.5.1 5.B.5.2 5.B.5.3 ISTE.2 ISTE.4 ISTE.6 RST.2 RST.4	3. Activity: Hooke's Law, Springs and PE • Students work with a partner to design and implement an experiment involving a spring and an increasing applied force. The data collected are represented in a graph that can be either hand-drawn or created with graphing software (Excel or Logger Pro). From the force-versus- distance graph, students should be able to calculate the work done on the spring. Students present whiteboards of their data and conclusions. Each student will write a formal self-reflection on the the experiment in the the form of a "letter home". Included in the reflection should be ways to improve the lab as well as real-world applications (such as shock absorbers on cars). • Objective: Students will design an experiment and analyze data using graphs and equations to determine Hooke's Law and potential energy and communicate these results with others. Appendix: 3.F-Hooke's Law, Springs and PE	Generating and testing hypothesis Nonlinguistic representations	D Communication
1, 2, 3	5.B.4.2 ISTE.2 ISTE.4 RST.4 RST.7 RST.8 WHST.4	4. Activity: Energy Bar Chart Energy bar charts are used in physics to show the relative types of energy in a system at particular points in time, as well as how the energy types are transforming within the system • Students work in pairs to create exercises that involve translation from one representation to another. Some possible translations are:	Cooperative learning Cues, questions, and advance organizers	C Collaboration

		• from a bar chart to a mathematical representation; • from a physical situation diagram to a bar chart; and • from a given equation to a bar chart. ● Each pair exchanges its exercises with another pair. After the students work through the exercises they received, the pairs meet and offer constructive criticism on each other's solutions. ● Objective: Students will develop techniques to express data in different forms. Appendix: 3.G- Energy Bar Charts		
1, 2, 3	5.A.2.1 5.B.5.4 5.B.5.5 4.C.2.1 4.C.2.2 5.B.2.1 ISTE.1 ISTE.2 ISTE.3 ISTE.4 RST.2 RST.4 WHST.5	5. Activity: Conservation of Energy Lab ● Students working in teams of three design and implement an experiment to determine the energy dissipated by friction of a system consisting of a modified Atwood's machine. The students are given the coefficient of friction of the block that is pulled across a surface, as well as the masses of the block and the hanging mass. Students are not permitted to use any additional equipment other than a meter stick. In their lab report, students must include the system(s) selected, bar charts, mathematical representations, data analysis, and an explanation of uncertainties in their measurements while indicating the importance of this information as it relates to real-word application. ● Objective: Students will be able to develop a working hypothesis on how friction functions in a system and be able to mathematically describe it. Appendix: 3.H-Conservation of Energy Lab	Generating and testing hypotheses Cooperative learning	D Critical Thinking

UNIT RESOURCES

Teacher Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim
- https://secure-pgp.wikispaces.com/home
- http://apphysicslinks.weebly.com/teaching-ap-physics.html
- http://www.wikipremed.com/01physicscards.php?card=2
- https://sites.google.com/site/apphysicsinquiry/home
- https://www.youtube.com/user/bohacekphysics/videos
- http://modelinginstruction.org/
- http://www.islephysics.net/
- http://dev.physicslab.org/Default.aspx
- http://ninenet.pbslearningmedia.org/collection/npe11/
- http://noschese180.wordpress.com/
- http://www.learner.org/courses/physics/index.html

Student Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- https://phet.colorado.edu/en/simulations/category/physics
- http://hypertextbook.com/
- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Energy – the ability to do work.

Work – the product of the magnitude of the displacement times the component of the force parallel to the displacement (W=Fd).

Net Work – the change in kinetic energy of the system.

Kinetic Energy – the energy of motion.
Potential Energy – energy associated with forces that depend on the position or configuration of an object relative to its surroundings.
Gravitational Potential Energy – energy due to the height of an object above the ground.
Elastic Potential Energy – energy in a spring or rubber band that is proportional to the square of the amount of stretch.
Conservative Forces – the amount of work done does not depend on the path taken only the initial and final positions.
Non-conservative forces – the amount of work done does depend on the path taken.
Principle of conservation of mechanical energy – if only conservative forces do work, the total mechanical energy of a system neither increases nor decreases in any process.
Law of conservation of energy – the total energy is neither increased nor decreased in any process. Energy can be transferred from one form to another, and transferred from one object to another, but the total amount remains constant.
Dissipative forces – reduce mechanical energy, but not the total energy, friction is an example of one.
Power – the rate at which work is done, work done divided by the time to do it.

Content Area: Science	Course: AP Physics 1	UNIT 4: Impulse, Momentum, and Conservation of Momentum

Unit Description:	Unit Timeline:
The study of accelerating forces in time and the conservation of forces and momentum in collision situations.	Approx. 4 Weeks

DESIRED Results
<u>Transfer Goal</u> - ***Students will be able to independently use their learning to……*** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>**Understandings**</u> **–** ***Students will understand that… (Big Ideas)***

1. Predicting the change in momentum of an object can be determined from the average force exerted on the object and the interval of time during which the force is exerted.
2. Performing an analysis of a force-time graph can predict the change in the momentum of a system.
3. Defining open and closed systems for everyday situations will assist in applying conservation concepts to energy and linear momentum in those systems.
4. Applying mathematical routines to problems involving elastic and inelastic collisions in one and two dimensions and justify the selection of the mathematical models based on conservations of momentum and restoration of kinetic energy

<u>**Essential Questions**</u>**:** ***Students will keep considering…***
● How does a force exerted on an object change the object's momentum? ● How are Newton's second and third laws related to momentum? ● What does it mean for momentum to be conserved? ● How can the outcome of a collision be used to characterize a collision an elastic or inelastic?

Students will know…..	Standard	Students Will Be Able to…..	Standard
The change in momentum of an object is a vector in the direction of the net force exerted on the object.	3.D.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.	**3.D.1.1**
The change in momentum of an object occurs over a time interval.	3.D.2		
The change in linear momentum for a constant-mass system is the product of the mass of the system and the change in velocity of the center of mass.	4.B.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.	**3.D.2.1**
The change in linear momentum of the system is given by the product of the average force on that system and the time interval during which the force is exerted.	4.B.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.	**3.D.2.2**
For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.	5.A.2	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.	**3.D.2.3**
In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.	5.D.1	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.	3.D.2.4
In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.	5.D.2	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.).	**4.B.1.1**
The velocity of the center of mass of the system cannot be changed by an interaction within the system.	5.D.3	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	**4.B.1.2**

		center of mass.	
		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.	4.B.2.1
		The student is able to perform analysis on data presented as a force-time graph and predict the change in momentum of a system.	**4.B.2.2**
		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.	**5.A.2.1**
		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.	**5.D.1.1**
		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.	5.D.1.2
		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.	5.D.1.3

		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.	5.D.1.4
		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.	5.D.1.5
		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.	5.D.2.1
		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.	5.D.2.2
		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.	5.D.2.3
		The student is able to analyze data that verify conservation of momentum in collisions with and without an external friction force.	**5.D.2.4**
		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	**5.D.3.1**

		(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). <u>Common Core Reading Standards for Grades 11 - 12</u> Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when	 RST.1 RST.2 RST.3 RST.4 RST.6 RST.7 RST.8

		possible and corroborating or challenging conclusions with other sources of information. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. <u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that	RST.9 WHST.1

		follows from or supports the argument presented.	
		Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).	WHST.2
		Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience	WHST.5
		Conduct short as well as more sustained research	

		projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	WHST.7
		Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities	ISTE.1
		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. a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems	ISTE.2
		Research and information fluency. Students apply digital tools to gather, evaluate,	ISTE.3

		and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	 ISTE.4

EVIDENCE of LEARNING

Understanding	Standards	Unit Performance Assessment:	R/R Quadrant
1,2,3,4	**3.D.1.1** **3.D.2.1** **3.D.2.2** **3.D.2.3** **4.B.1.1** **4.B.1.2** **4.B.2.2** **5.A.2.1** **5.D.1.1** **5.D.2.4** **5.D.3.1** RST.2 RST.4 RST.6 RST.7 RST.8 WHST.1	**Description of Assessment Performance Task(s):** Students will interrelate mass and velocity to momentum and kinetic energy. Students will analyze collision types and determining conservation of energy and momentum variables. See Appendix - 4.A Unit 4 - Momentum Performance Task. **Teacher will assess:** 1. Students abilitiy to demonstrate the relationship between momentum and kinetic energy. 2. The students ability to determine the difference between types of collisions and the energy and momentum calculations involved. 3. The students understanding of the use force - time graphs and how impulse changes momentum. **Performance:** **Mastery:** Students will show that they really understand when they… achieve a 80% mastery on the performance task.. **Scoring Guide:** See Appendix ______4.C Unit 4 - Momentum Assessment Blueprint Template and 4.B Unit 4 - Momentum Performance Task Rubric	C **21 Century** Critical Thinking

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 4 - 04 Unit 4 - Momentum Pre-Assessment. Includes answer key.

Understanding	Standards	Major Learning Activities: Activities are designed to prepare students for AP Test items.	Instructional Strategy:	R/R Quadrant:

				21 Century
1	3.D.2.2 3.D.2.3 ISTE.1 ISTE.2 ISTE.4 RST.2 WHST.7	1. Activity: Egg Toss-Impulse, Force and Time • This teacher-led demonstration of impulse, that uses raw eggs. Students are asked to predict the outcome of each of the following activities: 1.. A student volunteer throws an egg against one of the whiteboards. 2. The student throws an egg at a loosely held sheet. • For each activity, students use mobile devices and a classroom feedback tool (Socrative) to submit predictions. The class then votes for one of the predictions, and we conduct the activity. (Use large trash bags to protect the floor and the whiteboard.) If the result of the activity differs from the class's prediction, I guide the discussion to elicit an explanation of the phenomena observed. (The idea of impulse is addressed in this activity. This brings up a common misconception that the egg breaking on the board is a result of a large impulse, when in actuality it is the large force over a short time that results in the egg breaking) • Objective: Students will understand how to develop the idea of impulse. Appendix:4.D-Egg Toss	Reinforcing effort and providing recognition	B Critical Thinking
2	3.D.2.4 4.B.1.1 4.B.2.2 ISTE.1 ISTE.3 ISTE.4 RST.6 RST.8	2. Activity: Bumper Design Competition • Students design a paper bumper, as homework, that will soften the impact of the collision between a cart and a fixed block of wood. Their designs are evaluated by the shape of an acceleration-versus-time graph of the collision. Students will share designs to allow for formal student feedback to improve designs while allowing for formal reflecting on one's own design. Students from the PLTW classes will be asked to watch in the	Homework and practice Setting objectives and providing feedback	C Creativity

		testing part of this experiment. • Objective: Students will be able to design and practice team building projects to reduce the force of collisions in accidents. Appendix:4.E-Bumper Design Competition		
1, 2	3.D.1.1 3.D.2.1 3.D.2.3 3.D.2.4 4.B.2.1 4.B.2.2 ISTE.1 ISTE.2 ISTE.4 RST.2 RST.6 WHST.5	3. Activity: Activity: Impulse Lab • Students working in groups of three or four use a motion detector and a force sensor to measure the change in momentum of a dynamics cart and compare it to the impulse received. Students can give a small push to the cart or use the spring plunger to release the cart. The formal lab report includes the students' experimental design, collected data, graphical analysis, and conclusions. Students should account for uncertainties in their measurements and how the uncertainties affect the reliability of their results along with a persuasive writing and reflection on what could been done to improve the experiment if given the opportunity to test again. • Objective: Students will be able to design and implement experiments to collect data and analyze numerically and graphically for the interaction of impulse and momentum. Appendix: 4.F-Impulse Lab	Summarizin g and note taking Homework and practice	C Critical Thinking Collaboration
2	4.B.1.2 4.B.2.1 4.B.2.2 RST.4 RST.7	4. Activity: Solving Practice Problems • Objective: Students will know how to work through n-Tipers (Rally Table) that involve impulse and change of momentum as well as graphs of force versus time. Appendix: 4.G-Practice Problems	Kagan Cooperative learning	A Communication

4	5.A.2.1 5.D.1.1 5.D.1.2 5.D.1.3 5.D.3.1 ISTE.2 ISTE.4 RST.1 RST.8 RST.9 WHST.2	5. Activity: Qualitative Reasoning Tasks ● For the initial condition students are given the signs of the position and the net force. They also know whether the kinetic energy is increasing or decreasing. They have to determine the direction and whether the magnitude of the resultant momentum is increasing or decreasing. Students work with a partner in a task that requires a qualitative analysis of momentum. The task involves a scenario such as an object moving in one dimension. The task presents an initial and final situation and students must describe some quantity or aspect that has changed between the initial and final situation. ● Objective: Students will know how to qualitatively evaluate interactions of KE and momentum in different scenarios. Appendix: 4.H-Qualitative Reasoning Tasks	Generating and testing hypothesis	B Collaboration
4	5.D.1.4 5.D.1.5 5.D.2.1-2.5 ISTE.1-.2	6. Activity: Collisions and Explosions Lab ● Students work in groups of three or four to design an experiment to investigate conservation of momentum and conservation of energy using an air track with gliders. ● Objective: Students will understand conservation of momentum and energy and how they are related in different collisions. Appendix: 4.I-Collisions and Explosions Lab	Identifying similarities and differences	D Critical Thinking Communication Collaboration
2, 3	5.D.1.4 5.D.2.3 5.D.2.4 4.B.1.1 4.B.1.2 ISTE.1 ISTE.3 ISTE.4 RST.3 RST.6 WHST.1 WHST.2	7. Activity: Sand Balloon Pendulum Lab ● Students use a pendulum bob (a small balloon filled with flour or sand) that swings down from a horizontal position and hits the tissue box. The box slides across the table and eventually stops. Students work in teams of three or four to design and conduct their experiment to determine the coefficient of friction between the box and the table. Students will discuss the results and what they could of done differently to improve the experimental design. ● Objective: Students will be able to quantitatively evaluate PE, KE, and the conservation of energy and momentum along with write a formal argument supporting the results. Appendix: 4.J-Sand Balloon Pendulum	Cooperative learning Setting objectives and providing feedback	C Creativity Collaboration

UNIT RESOURCES

Teacher Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim
- https://secure-pgp.wikispaces.com/home
- http://apphysicslinks.weebly.com/teaching-ap-physics.html
- http://www.wikipremed.com/01physicscards.php?card=2
- https://sites.google.com/site/apphysicsinquiry/home
- https://www.youtube.com/user/bohacekphysics/videos
- http://modelinginstruction.org/
- http://www.islephysics.net/
- http://dev.physicslab.org/Default.aspx
- http://ninenet.pbslearningmedia.org/collection/npe11/
- http://noschese180.wordpress.com/
- http://www.learner.org/courses/physics/index.html

Student Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- https://phet.colorado.edu/en/simulations/category/physics
- http://hypertextbook.com/
- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Linear Momentum – also known as momentum is the product of mass and velocity, a vector quantity.

Second Law of Motion – the rate of change of momentum of an object is equal to the net force applied to it.

Law of conservation of momentum – The total momentum of an isolated system of objects remain constant.

Impulse – force multiplied by time.
Elastic collisions – collision in which the total kinetic energy is conserved.
Inelestic collision – collision in which kinetic energy is lost and changed into other forms of energy as thermal or others.
Completely inelastic collisions – collisions where the two objects stick together after the collision.
Center of Mass – if an object rotates, or several parts of a system of objects move relative tone another, there is a point that moves in the same path that a particle would move if subjected to the same net force.
Center of Gravity – the point on an object where at which the force of gravity can be considered to act.

Content Area: Science	Course: AP Physics 1	UNIT 5: Circular Motion and Gravitation

Unit Description:	Unit Timeline:
Study of the forces required to overcome an object's inertia in order to get it to move in a circular path.	3 weeks

DESIRED Results
<u>Transfer Goal</u> - ***Students will be able to independently use their learning to……*** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>Understandings</u> **– *Students will understand that… (Big Ideas)***

1. Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of an object moving in a circular path.
2. Apply Newtons Universal law of gravity to an object that is in free-fall around a central mass.
3. Approximate a numerical value of the gravitational field near the surface of an object from its radius and mass relative to those of the Earth and other reference objects.

<u>Essential Questions</u>: *Students will keep considering…*
● What force or combination of forces keep an object in circular motion. ● How is the motion of the moon around the Earth like the motion of a falling apple.. ● How does the effect of Earth's gravitational field on an object change as the object's distance from Earth changes.

Students will know…..	Standard	Students Will Be Able to…..	Standard
Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.	1.C.2	The student is able to design a plan for collecting data to measure gravitational mass and inertial mass, and to distinguish between the two experiments.	**1.C.3.1**
Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.	1.C.3	The student is able to apply F=mg 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.	**2.B.1.1**
A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.	2.A.1	The student is able to apply g=GM/r^2 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.	**2.B.2.1**
A gravitational field g at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field.	2.B.1	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.	**2.B.2.2**
The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object.	2.B.2	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.	**3.C.1.1**
Forces are described by vectors.	3.A.2	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.	3.A.2.1
A force exerted on an object is always due to the interaction of that object with another object	3.A.3	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.	3.A.3.1
If an object is of interest interacts with several other objects, the net force is the vector sum of the individual forces.	3.B.1	The student is able to describe a force as an interaction	3.A.3.3
Free body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.	3.B.2		
Gravitational force describes the interaction of one object	3.C.1		

that has mass with another object that has mass.		between two objects and identify both objects for any force. 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. 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. The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. 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 circular orbital motion. Common Core Reading Standards for Grades 11 - 12 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or	 3.B.1.2 3.B.2.1 3.B.1.3 **3.C.1.2** RST.1 RST.2 RST.3

		performing technical tasks; analyze the specific results based on explanations in the text.	
		Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.	RST.4
		Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	RST.6
		Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	RST.7
		Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	RST.8
		By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.	RST.10
		<u>Common Core Writing Standards for Grades 11-12</u>	
		Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims,	WHST.1

		reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.	 WHST.2

		c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).	
		Produce writing in which the organization, development, substance, and style are appropriate to task, purpose, and audience.	WHST.4
		Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.	WHST.8
		Draw evidence from informational texts to support analysis, reflection, and research.	WHST.9
		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. a. Interact, collaborate, and publish with peers,	ISTE.2

		experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems	
		Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results	ISTE.3
		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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	ISTE.4

		Digital citizenship Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. a. Advocate and practice safe, legal, and responsible use of information and technology b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity c. Demonstrate personal responsibility for lifelong learning d. Exhibit leadership for digital citizenship Technology operations and concepts. Students demonstrate a sound understanding of technology concepts, systems, and operations. a. Understand and use technology systems b. Select and use applications effectively and productively c. Troubleshoot systems and applications d. Transfer current knowledge to learning of new technologies	ISTE.5 ISTE.6

EVIDENCE of LEARNING

Understanding	Standards	**Unit Performance Assessment**:	**R/R Quadrant**
1,2,3	**1.C.3.1** **2.B.1.1** **2.B.2.1** **2.B.2.2** **3.C.1.1** **3.C.1.2** RST.2 RST.4 RST.8 RST.10 WHST.1 WHST.2 WHST.4	**Description of Assessment Performance Task(s):** See Appendix - 5.A Unit 5 - Circular Motion and Gravitation Performance Task. **Teacher will assess:** 1. The students ability to use vectors and force diagrams to describe and analyze circular motion. 2. The students ability to use Newton's Universal Law of Gravity to determine satellite motion, planetary motion, and gravity constants on other planets. **Performance:** **Mastery:** Students will show that they really understand when they… achieve a 80% mastery on the performance task.. **Scoring Guide:** See Appendix ______5.C Unit 5 - Circular Motion and Gravitational Assessment Blueprint Template and 5.B Unit 5 - Circular Motion and Gravitational Performance Task Rubric	C **21 Century** Critical Thinking

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 5 - 05 Unit 5 - Circular Motion Pre-Assessment. Includes answer key.

Understanding	**Standards**	**Major Learning Activities: Activities are designed to prepare students for AP Test items.**	**Instructional Strategy:**	**R/R Quadrant:** **21 Century**
1	3.A.3.3 3.A.3.1 3.A.2.1 3.B.1.2 3.B.1.3 3.B.2.1 ISTE.3 ISTE.4 RST.2 RST.3 RST.4	1. Activity: Flying Pig Lab ● Students work in groups of three or four to design and implement an experiment involving a battery-operated flying toy that is attached to a string and swung in a horizontal circle. Students must find the tension in the string and the centripetal acceleration of the toy. Students will have an opportunity to formally evaluate other group results while self-reflecting on own results. ● Objective: Students will know how to quantitatively determine circular motion variable in a lab. Appendix Document: 5.D Unit 5 - Flying Pig Lab	Homework and practice Cooperative learning	B Creativity
1	3.A.3.1 ISTE.2 ISTE.4 RST.1 RST.2 RST.4 WHST.1 WHST.4	2. Activity: NTiper - Cars going in circles ● Students are given multiple-choice tasks that present different variations of a physical situation with answers that include possible outcomes. For example, the situation could be a roller coaster car in a vertical loop. Questions can ask for the minimum speed at the top of the loop when the car is inverted, and the maximum speed when the car has returned to the bottom of the loop. Variations can include a car at the top of a hill, and then at the bottom of the hill. Students pass their responses to a classmate and we score the assessment as a group. Students then return the scored sheets to their peers. (Think-write-roundrobin) For each incorrect item, students	Kagan Reinforcing effort and providing recognition	C Collaboration Critical Thinking

		write a brief statement explaining why they missed the item (formal evaluation). ● Objective: Students will be able to demonstrate their knowledge of circular motion and the forces associated with it. Appendix Document: 5.E Unit 5 - NTipper - Cars going in circles		
2	3.C.1.1 2.B.2.1 2.B.2.2 ISTE.2 ISTE.3 RST.2 RST.3	3. Activity: Two Planetary Objects ● The video “The Apple and the Moon” serves as a good introduction to Isaac Newton’s life and the work that led to his universal law of gravitation. The video helps students understand how Newton reconciled Galileo’s ideas about kinematics with Kepler’s work in astronomy. After watching the video, we have a discussion about the accomplishments of Isaac Newton and how the physics principles that will be uncovered in this unit paved the way for astronauts to reach the moon. ● Objective: Students will know and gain an appreciation of Newton’s life and work and how he contributed to the our modern day physics and space exploration. Appendix Document: 5.F Unit 5 - NTiper - Two Planetary Objects	Summarizing and note taking	A Communication
3	2.B.1.1 3.C.1.2 3.C.1.1 ISTE.2 ISTE.3 ISTE.4 ISTE.6 RST.2 RST.7 WHST.2 WHST.4 WHST.8	4. Activity: My Solar System Simulation ● In this virtual lab, students use the “My Solar System” simulation to investigate the effects of mass and distance on the velocity of objects in orbit. Students report the collected data, their data analysis, and a conclusion in their lab journals where they will formally reflect. ● Objective: Students will be able to demonstrate and explain that distance is proportional and mass is inversely proportional to the speed of a rotating object.	Summarizing and note taking Nonlinguistic representation	B Communication

		Appendix Document: 5.G Unit 5 - My Solar System Simulation		
3	2.B.2.1 2.B.2.2 ISTE.2 ISTE.3 ISTE.4 RST.2 RST.6	5. Activity: Orbits of Mars and Mercury ● Objective: Students will be able to analyze data from the Apollo 11 lunar mission to find the gravitational field at different distances. Appendix Document: 5.H Unit 5 - Orbits of Mars and Mercury	Identifying similarities and differences	C Critical Thinking
2, 3	3.G.1.1 ISTE.2 ISTE.3 ISTE.5 RST.10 WHST.1 WHST.2 WHST.4 WHST.8 WHST.9	6. Assessment: Research Paper ● Students write a persuasive research paper in response to two prompts: 1. Explain what is meant by the Newtonian synthesis and its relevance in changing the way people thought about nature. 2. Discuss how the exploration of space is possible because of Isaac Newton's work. ● Through this assignment, students demonstrate their ability to work and think independently and to apply the concepts they have learned in class, primarily the application of Newtons laws of motion. ● Objective: Students will be able to practice scientific paper writing skills and gain knowledge about Newton's contributions. Appendix Document: 5.I Unit 5 Grading Rubric for Research Paper	Summarizing and note taking Cues, questions, and advance organizers	D Creativity Critical Thinking

UNIT RESOURCES
Teacher Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim ● https://secure-pgp.wikispaces.com/home ● http://apphysicslinks.weebly.com/teaching-ap-physics.html ● http://www.wikipremed.com/01physicscards.php?card=2 ● https://sites.google.com/site/apphysicsinquiry/home ● https://www.youtube.com/user/bohacekphysics/videos ● http://modelinginstruction.org/ ● http://www.islephysics.net/ ● http://dev.physicslab.org/Default.aspx ● http://ninenet.pbslearningmedia.org/collection/npe11/ ● http://noschese180.wordpress.com/ ● http://www.learner.org/courses/physics/index.html
Student Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● https://phet.colorado.edu/en/simulations/category/physics ● http://hypertextbook.com/ ● https://prettygoodphysics.wikispaces.com/home ● http://www.learnapphysics.com/ ● https://www.youtube.com/user/bohacekphysics/videos ● http://www.physicsclassroom.com/ ● http://dev.physicslab.org/Default.aspx ● http://www.cyberphysics.co.uk/index.html ● **Online video** “The Apple and the Moon” ● **Web Phet** “My Solar System” simulation

- **Web** “Episode 402-3: Data from the Apollo 11 mission

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Uniform circular motion – an object that moves in a circle at a constant speed.

Centripetal acceleration – acceleration that points to the center of the circle also called radial acceleration.

Frequency – the number of revolutions per second.

Period – the time for one complete revolution.

Law of Universal Gravitation – every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them. This force acts along the line joining the two particles.

Geosynchronous satellite – a satellite that stays above the same point on earth.

Kepler’s First Law – the path of each planet around the sun is an ellipse with the sun at one focus.

Kepler’s Second Law – Each planet moves so that an imaginary line drawn from the sun to the planet sweeps out equal areas I equal periods of time.

Kepler’s Third Law – the ratio of the squares of the periods of any two planets revolving around the sun is equal to the ratio of the cubes of their mean distance from the sun.

Four fundamental forces – gravitational force, electromagnetic force, strong nuclear force, and weak nuclear forces.

Content Area: Science	Course: AP Physics I	UNIT 6: Rotational Motion and Conservation of Angular Momentum

Unit Description:	Unit Timeline:
The motion of a solid rotating object is studied.	4 weeks.

DESIRED Results

Transfer Goal - Students will be able to independently use their learning to……

- Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

Understandings – Students will understand that… (Big Ideas)

1. Torque is the rotational analog to force and the Moment of inertia is the rotational analog to mass.
2. The motion of stellar bodies can be described by Newton's Laws.
3. The equations for linear motion, Newton's second law, and momentum all have analogues in rotational motion.
4. Angular velocity is the same for all points on a rigid rotating body.

Essential Questions: Students will keep considering…

- How can the particle model be extended to a rigid-body model of an object?
- How are the rotational quantities (angular position, velocity, and acceleration) related to linear quantities?
- What does it mean for angular momentum to be conserved?
- How are rotational motion concepts applied to the motion of stellar bodies?

Students will know…..	Standard	Students Will Be Able to…..	Standard
Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis.	3.F.1	The student is able to use representations of the relationship between force and torque.	**3.F.1.1**
The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.	3.F.2	The student is able to compare the torques on an object caused by various forces.	**3.F.1.2**
		The student is able to estimate the torque on an object caused by various forces in comparison to other situations.	**3.F.1.3**
A torque exerted on an object can change the angular momentum of an object.	3.F.3	The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system.	**3.F.1.4**
The angular momentum of a system may change due to interactions with other objects or systems.	4.D.2		
The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.	4.D.3	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).	**3.F.1.5**
For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.	5.A.2	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.	**3.F.2.1**
If the net external torque exerted on the system is zero, the angular momentum of the system does not change.	5.E.1	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.	3.F.2.2
The angular momentum of a system is determined by the locations and velocities of the objects that make up the system. The rotational inertia of an object or system depends upon the distribution of mass within the object or system. Changes in the radius of a system or in the	5.E.2	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	3.F.3.1

distribution of mass within the system result in changes in the system's rotational inertia, and hence in its angular velocity and linear speed for a given angular momentum. Torque, angular velocity, angular acceleration, and angular momentum are vectors and can be characterized as positive or negative depending upon whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis.	4.D.1	angular impulse and change of angular momentum.	
		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.	**3.F.3.2**
		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.	3.F.3.3
		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.	**4.D.2.1**
		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.	4.D.2.2
		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.	4.D.3.1
		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.	4.D.3.2
		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. 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.	**5.A.2.1**
		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.	5.E.1.1
		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.	**5.E.1.2**
		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.	5.E.2.1
		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.	**4.D.1.1**
		<u>Common Core Reading Standards for Grades 11 - 12</u>	
		Cite specific textual evidence to support analysis of science and technical texts, attending to important	RST.1

		distinctions the author makes and to any gaps or inconsistencies in the account. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. <u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on discipline-specific	 RST.2 RST.3 RST.4 RST.6 RST.7 RST.8 WHST.1

		content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented.	
		Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and	WHST.2

		multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).	
		Students' narrative skills continue to grow in these grades. The Standards require that students be ab le to incorporate the narrative elements effectively into arguments and information/explanatory texts. In science, students must be able to write precise descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.	WHST.3
		Produce writing in which the organization, development, substance, and style are appropriate to task, purpose, and audience.	WHST.4
		Creativity and innovation. Students demonstrate creative thinking, construct	ISTE.1

		knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities 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. a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other cultures d. Contribute to project teams to produce original works or solve problems Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks	ISTE.2 ISTE.3

		d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	ISTE.4

EVIDENCE of LEARNING

Understanding	Standards	Unit Performance Assessment:	R/R Quadrant
1,3,4	**3.F.1.1** **3.F.1.2** **3.F.1.3** **3.F.1.5** **3.F.2.1** **3.F.3.2** **4.D.1.1** **4.D.2.1** **5.A.2.1** **5.E.1.2** ISTE.3 RST.1 RST.2 RST.7 WHST. 2 WHST.4	**Description of Assessment Performance Task(s):** See Appendix - 6.A Unit 6 - Rotational Motion Performance Task **Teacher will assess:** What criteria will be used in each assessment to evaluate attainment of the desired results? 1. The students ability to understand torque and use torque to determine is a rotational system is accelerating or in equilibrium. The concept of torque being equivalent to linear force in a rotating system and being able to convert from linear to rotational momentum by calculations and by deriving formulas. The students will demonstrate their understanding of rotational inertia by deriving formulas for different scenarios. **Performance:** **Mastery:** Students will show that they really understand when they… achieve a 80% mastery on the performance task. **Scoring Guide:** See Appendix ______6.C Unit 6 - Rotational Motion Assessment Blueprint Template and 6.B Unit 6 - Rotational Motion Performance Task Rubric	C **21 Century** Critical Thinking

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 6 - 06 Unit 6 - Rotational Motion Pre-Assessment. Includes answer key.

Understanding	Standards	Major Learning Activities: Activities are designed to prepare students for AP Test items.	Instructional Strategy:	R/R Quadrant: 21st Century
1	3.F.1.1 3.F.1.2 3.F.1.3 3.F.1.4 3.F.1.5 ISTE.1 ISTE.2 ISTE.3 RST.1 RST.2 RST.3 RST.4 WHST.2 WHST.4	1. Activity: Torque and the Human Arm ● Students work in groups of three (Find Someone Who) or four to design and build an apparatus that replicates the forearm and biceps muscle system. The objective is to determine the biceps tension when holding an object in a lifted position. Students may use the Internet to research the structure of the biceps muscle. They can use readily available materials in the classroom, such as a meterstick, a ring stand, weight hangers, an assortment of blocks, and a spring scale. In their lab journal, students are required to document the different stages of their design. Required elements include design sketches, force diagrams, mathematical representations of translational and rotational equilibrium, and numerical calculations. Students will prepare a presentation using Prezi. PLTW biomed, and Human Anatomy classes will be asked to attend student lead presentations. ● Objective: Students will be able to design and learn how physics and torque can apply to the human body. Students will also have the opportunity to formally critique other groups findings. Appendix Document: 6.D Unit 6 - Torque and the Human Arm	Cooperative learning	D Collaboration Critical Thinking Creativity
4	4.D.1.2 4.D.1.1 5.A.2.1 5.E.1.2 ISTE.1 RST.4 RST.6	2. Activity: The Physics of Juggling ● After watching a demonstration of someone juggling, I ask for volunteers to explain in their own words the concept of center of mass in the parabolic motion of objects being juggled. ● Objective: Students will understandf how physics and rotational motion is used in everyday life to explain processes. Appendix Document: 6.E Unit 6 - The Physics of Juggling	Nonlinguistic representation	B Creativity

3,4	3.F.2.1 4.D.1.1 5.A.2.1 5.e.E.2.1 ISTE.1 ISTE.2 ISTE.4 RST.2 RST.3 RST.8 WHST.1 WHST.3 WHST.4	3. Activity: Rotational Inertia Lab ● This teacher-led demonstration involves a suspended (vertically mounted) bicycle wheel, with a string wrapped around the wheel's rim. One end of the string is attached to the wheel, and the other is attach to a small mass. The mass is released, causing the wheel to rotate. The students create a video and import into LoggerPro for the video analysis function to determine the rotational inertia of the wheel. ● Objective: Students will gain an understanding of rotational inertia and how motion is affected. Appendix Document: 6.F Unit 6 - Rotational Inertia Lab	Genertating and testing hypotheses	C Critical Thinking
3,4	3.F.2.2 4.D.1.1 5.A.2.1 5.E.2.1 ISTE.2 ISTE.3 ISTE.4 RST.1 RST.7 RST.8 WHST.1 WHST.2	4. Activity: Rotational Kinematics ● Students work with a partner to design and implement a data collection plan to determine the rotational inertia of a cylinder from the slope of a graph of an applied torque versus angular acceleration. The students are able to verify their claims by formally comparing their evidence with the rotational inertia found directly by measuring the mass and radius of the cylinder. ● Objective: Students will analyze graphical data to make a prediction about an object and then determine if their predictions are true. Appendix Document: 6.G Unit 6 - Rotational Kinematics	Cues, questions, and advance organizers	B Collaboration
3,4	3.F.3.1 3.F.3.2 3.F.3.3 4.D.1.1 4.D.1.2 4.D.2.1	5. Activity: Angular Momentum Lab ● In pairs or small groups (Timed Pair Share), students investigate how the angular momentum of a rotating system responds to changes in the rotational inertia. The experiment involves the collection of data of angle versus time and angular velocity versus time. Students use a LabQuest connected to a rotary motion sensor with an aluminum plate that is spun to a certain	Identifying similarities and differences	C Critical Thinking

	4.D.2.2 4.D.3.1 4.D.3.2 ISTE.2 ISTE.3 ISTE.4 RST.1 RST.7 RST.8 WHST.1 WHST.2	angular speed, and then a second plate is dropped onto the first one, resulting in a change of the moment of inertia and the angular speed. The students use LoggerPro to analyze the graphs before and after the changes in the rotational inertia and determine the effect of changes in the rotational inertia on the angular momentum of the system. ● Objective: Students will be able to develop an understanding of angular momentum and interactions with rotational inertia by analyzing collected data. Appendix Document: 6.H Unit 6 - Angular Momentum Lab		
2	5.E.1.1 5.E.1.2 ISTE.2 ISTE.3 ISTE.4 RST.1 RST.2 RST.4 RST.6 WHST.1	6. Activity: Kepler's Laws ● Objective: Students will know how to use data period and radius to plot planetary orbits and then analyze the orbit by applying Kepler's laws. Appendix Document: 6.I Unit 6 - Keplers Laws	Summarizing and note taking	A Communication
1,3,4	5.E.1.1 4.D.2.1 RST.2 RST.7	7. Activity: NTiper Angular Momentum ● Students are given a couple of problems involving two objects of different masses hanging from a massive pulley. They are then given conflicting statements about the tension of the rope at specific points and then about each object's angular acceleration as the objects are released from rest. The students have to decide which contention they agree with and validate why. Students work their solution on a whiteboard with a partner. This task is useful for contrasting statements of students' alternative conceptions with physically accepted statements. The task can be phrased as "Which statement do you agree with and why?" rather than asking which statement	Nonlinguistic representation Cooperative learning	D Critical Thinking

		is correct or true. Students will develop formal arguments and be able to critique the reasoning of others. ● Objective: Students will be able to create an argumentative writing session about the different problems and determine which statements are true. Appendix Document: 6.J Unit 6 - NTiper Angular Momentum		

UNIT RESOURCES
Teacher Resources: This may include: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim ● https://secure-pgp.wikispaces.com/home ● http://apphysicslinks.weebly.com/teaching-ap-physics.html ● http://www.wikipremed.com/01physicscards.php?card=2 ● https://sites.google.com/site/apphysicsinquiry/home ● https://www.youtube.com/user/bohacekphysics/videos ● http://modelinginstruction.org/ ● http://www.islephysics.net/ ● http://dev.physicslab.org/Default.aspx ● http://ninenet.pbslearningmedia.org/collection/npe11/ ● http://noschese180.wordpress.com/ ● http://www.learner.org/courses/physics/index.html
Student Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● https://phet.colorado.edu/en/simulations/category/physics ● http://hypertextbook.com/

- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Angular Position – how far an object has rotated by angle theta to a reference line.

Radian – the angle subtended by an arc whose length is equal to the radius.

Angular velocity – is analogous to linear velocity but using angular displacement instead.

Angular acceleration – is analogous to linear acceleration, it is the change in angular velocity divided by the time required to make the change.

Constant angular acceleration – can use the angular equations analogous to the linear kinematic .

Lever arm – sometimes called moment arm, the perpendicular distance from the axis of rotation to the line along which the force acts.

Torque – force times the lever arm.

Moment of Inertia – also called rotational inertia, plays the same role as mass does for translational motion.

Rotational Kinetic Energy – similar to linear kinetic energy except the object is rotating about an axis.

Angular momentum –analogous to linear momentum.

Law of conservation of angular momentum – the total angular momentum of a rotating object remains constant if the net torque acting on it is zero.

Content Area: Science	Course: AP Physics 1	UNIT 7: Simple Harmonic Motion, Mechanical Waves and Sound

Unit Description:	**Unit Timeline:**
A special type of motion, called simple harmonic motion, is analyzed. The transmission of energy by waves and the case of mechanical waves thru material is discussed	2 Weeks

DESIRED Results
<u>Transfer Goal</u> - **Students will be able to independently use their learning to……** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>Understandings</u> **– Students will understand that… (Big Ideas)**

1. Simple Harmonic Motion can be analyzed with forces, energy, and Newton's laws
2. Graphically SHM is shown to be sinusoidal in nature
3. Transverse and Longitudinal waves travel thru matter in different ways.

<u>Essential Questions</u>**: Students will keep considering…**

- What is the connection between simple harmonic motion and uniform circular motion?
- How can the inertial mass of an object be measured?
- How can waves transmit energy?
- How can sound waves be explained?
- What happens when two waves meet?

Students will know…..	Standard	Students Will Be Able to…..	Standard
Restoring forces can result in oscillatory motion. When a linear restoring force is exerted on an object displaced from an equilibrium position, the object will undergo a special type of motion called simple harmonic motion.	3.B.3	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.	**3.B.3.1**
A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy.	5.B.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.	**3.B.3.2**
Waves can propagate via different oscillation modes such as transverse and longitudinal.	6.A.1	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.	3.B.3.3
For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium.	6.A.2	The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force.	**3.B.3.4**
The amplitude is the maximum displacement of a wave from its equilibrium value.	6.A.3	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.	**5.B.2.1**
Classically, the energy carried by a wave depends upon and increases with amplitude. Examples should include sound waves.	6.A.4	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.	**6.A.1.1**
For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time.	6.B.1		
For a periodic wave, the wavelength is the repeat distance of the wave.	6.B.2		
For a periodic wave, wavelength is the ratio of speed over frequency.	6.B.4		
The observed frequency of a wave depends on the relative motion of source and observer. This is a	6.B.5		

qualitative treatment only. Two or more wave pulses can interact in such a way as to produce amplitude variations in the resultant wave. When two pulses cross, they travel through each other; they do not bounce off each other. Where the pulses overlap, the resulting displacement can be determined by adding the displacements of the two pulses. This is called superposition. Two or more traveling waves can interact in such a way as to produce amplitude variations in the resultant wave. Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. Examples should include waves on a fixed length of string, and sound waves in both closed and open tubes. The possible wavelengths of a standing wave are determined by the size of the region to which it is confined. Beats arise from the addition of waves of slightly different frequency.	 6.D.1 6.D.2 6.D.3 6.D.4 6.D.5	The student is able to describe representations of transverse and longitudinal waves. 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. The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. 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. 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. The student is able to use a visual representation of a periodic mechanical wave to determine wavelength of the wave. 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. 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. The student is able to use representations of individual	6.A.1.2 **6.A.2.1** 6.A.3.1 **6.A.4.1** 6.B.1.1 6.B.2.1 6.B.4.1 6.B.5.1 **6.D.1.1**

		pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses.	
		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).	6.D.1.2
		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.	6.D.1.3
		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.	6.D.2.1
		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.	6.D.3.1
		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.	6.D.3.2
		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.	**6.D.3.3**

		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.	6.D.3.4
		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.	6.D.4.1
		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.	**6.D.4.2**
		The student is able to use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats.	**6.D.5.1**
		<u>Common Core Reading Standards for Grades 11 - 12</u>	
		Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	RST.1
		Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	RST.2
		Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results	RST.3

		based on explanations in the text. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. <u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the	 RST.4 RST.7 RST.8 WHST.1

		text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.	WHST.2

		e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	 WHST.7
		Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities	ISTE.1
		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. a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats c. Develop cultural understanding and global awareness by engaging with learners of other	ISTE.2

		cultures d. Contribute to project teams to produce original works or solve problems Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	 ISTE.3 ISTE.4

EVIDENCE of LEARNING

<table>
<tr>
<td>Understanding

1,2,3</td>
<td>Standards

3.B.3.1
3.B.3.2
3.B.3.4
5.B.2.1
6.A.1.1
6.A.2.1
6.A.4.1
6.D.1.1
6.D.3.3
6.D.4.2
6.D.5.1
ISTE. 3
ISTE.4
RST.1
RST.2
RST.3
RST.4
WHST.1
WHST.2</td>
<td><u>Unit Performance Assessment</u>:
Description of Assessment Performance Task(s):
See Appendix - 7.A Unit 7 - Waves and Simple Harmonic Motion Performance Task

Teacher will assess:
What criteria will be used in each assessment to evaluate attainment of the desired results?
1. Students will be able to to use energy concepts, Newton’s Laws, Forces, and kinematics to make calculations and derive formulas with simple harmonic motion using and spring systema or pendulum. They will be able to interpret graphs of energy vs displacements to reason situations in SHM. The will demonstrate their knowledge of waves and sound to calculate values and answer conceptual questions. They will be able to draw force diagrams and derive equations for pendulum motion.
<u>Performance:</u>
Mastery:
Students will show that they really understand when they…
achieve a 80% mastery on the performance task.

Scoring Guide:
See Appendix _______
7.C Unit 7 - Waves and Simple harmonic Motion assessment blueprint template and 7.B Unit 7 - Waves and Simple Harmonic Motion Performance Task Rubric</td>
<td><u>R/R Quadrant</u>

C

<u>21st Century</u>

Critical Thinking</td>
</tr>
</table>

SAMPLE LEARNING PLAN
Pre-assessment: Please see Appendix for Unit 7 - 07 Unit 7 - Simple Harmonic Motion Pre-Assessment. Includes answer key.

Understanding	Standards	Major Learning Activities: Activities are designed to prepare students for AP Test items.	Instructional Strategy:	R/R Quadrant: 21st Century
1	6.D.3.2 6.D.3.3 ISTE.2 ISTE.3 ISTE.4 WHST.2	1. Activity: Spring Constant Investigation ● Objective: Students in small groups will be able to design two independent experiments to determine the spring constants of various springs of equal length. (I use sets of five color-coded equal-length springs.) The two approaches used by the students are applying Hooke's law and determining the period of oscillation. At the conclusion of this activity students are asked what they could do to improve the design/experiment and can be accomplished through persuasive writing and formal self-reflection. Appendix Document: 7.D Unit 7 - Spring Constant	Generating and testing hypotheses	B Creativity Critical Thinking
2	3.B.3.1 3.B.3.2 3.B.3.3 3.B.3.4 ISTE.2 ISTE.3 ISTE.4 RST.1 RST.7 RST.8 WHST.1	2. Activity: Graphs of an Oscillating System Investigation ● Objective: Students will work in groups of three or four to analyze graphs of position, velocity, and acceleration versus time for an oscillating system consisting of a dynamics cart attached to a spring. Important goals for this activity are for students to be able to compare how velocity and acceleration vary at the equilibrium position and at the endpoints. Students should also be able to articulate the role of the restoring force. ● NTipers nT9A-CRT11, nT9A-CRT12, nT9A-CRT13, and	Nonlinguistic representations	B Communication

	WHST.2	nT9A-CT5 Appendix Document: 7.E Unit 7 - NTiper Graphs of an Oscillating System		
1	3.B.3.1 3.B.3.2 ISTE.1 ISTE.3 RST.1 RST.2 RST.8 WHST.1 WHST.7	3. Activity: Sphere On A String • This lab investigation is divided into two parts. First the students work with a partner to investigate the factors that affect the period of a simple pendulum. In the second part of the lab, they test whether the period is proportional to the pendulum's length, the square of its length, or the square root of its length. (This test applies only when the amplitude of oscillation is small.) For this experiment the students use hooked cylindrical masses. It is important for the students to recognize that the length of the pendulum should be measured from the pendulum clamp to the center of mass of the cylindrical mass. • Objective: Students will experimentally determine the mathematical properties of a simple pendulum. Appendix Document: 7.F Unit 7 - NTiper Sphere On A String	Identifying similarities and differences	C Critical Thinking
1,2	6.A.1.1 6.A.1.2 6.A.3.1 6.D.3.1 ISTE.1 ISTE.3 RST.1 RST.2 RST.8 WHST.1 WHST.7	4. Activity: Wave Superposition • Objective: Students will be able to work in teams of three or four to model the two types of mechanical waves (longitudinal and transverse) with a spring toy. The students then design and implement an experiment to test whether the following characteristics affect the speed of a pulse: frequency, wavelength, and amplitude. At the end of this activity students will demonstrate and explain the difference between longitudinal waves and transverse waves. Appendix Document: 7.G Unit 7 Wave Superposition	Homework and practice	B Collaboration Critical Thinking
3	6.A.2.1	5. Activity: Speed of Sound Lab		D Communication

	6.A.4.1 6.B.4.1 6.D.4.1 ISTE.1 ISTE.3 RST.1 RST.2 RST.8 WHST.1 WHST.7	• Objective: Students will working in small groups and be able to design two different procedures to determine the speed of sound in air. They brainstorm their approaches and write them on the whiteboard. (Team Stand-N-Share) Each of the teams presents its ideas to the class. Students receive feedback from their peers and then conduct their experiments. They record the revised procedures in their lab journals. For the post-lab discussion, they match the teams that used similar procedures and discuss their results. Then reach a consensus about the estimated value for the speed of sound. Appendix Document: 7.H Unit 7 Speed of Sound Lab	Reinforcing effort and providing recognition	
3	6.B.1.1 6.B.2.1 6.B.5.1 6.D.3.4 6.D.4.2 ISTE.1 ISTE.3 RST.1 RST.2 RST.8 WHST.1 WHST.7	6. Activity: Types of Waves • Students work with a partner to create a concept map of the types of waves and characteristics of waves. (Jot Thoughts) A concept map is a diagram of nodes, each containing concept labels; the nodes are linked together with directional lines, also labeled. The concept nodes are arranged in hierarchical levels that move from general to specific concepts. • Objective: Students will understand that concept maps are a useful instructional strategy as they assess how well students see the “big picture” on a particular topic. The concept maps are to be illustrated with diagrams and include mathematical representations as appropriate. The students share their work by posting their concept maps online using a digital tool such as Exploratree. Appendix Document: 7.I Unit 7 - Types of Waves	Nonlinguistic representation	B Critical Thinking Creativity
3	6.D.1.1 6.D.1.2 6.D.1.3 6.D.2.1 6.D.5.1	7. Activity: Wave Boundary Behavior • Working in teams of three or four, students design and implement an experiment to compare what happens to the	Identifying similarities and differences	A Collaboration

	ISTE.1 ISTE.3 RST.1 RST.2 RST.8 WHST.1 WHST.7	phase of a transverse wave on a spring toy when a pulse is reflected from a fixed-end boundary and a free-end boundary, and when it is reflected and transmitted from various boundaries (spring to string). ● Objective: Students will know what happens to a transverse wave of a spring when different conditions are applied to the spring. Appendix Document: 7.J Unit 7 Wave Boundary Behavior		

UNIT RESOURCES
Teacher Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim ● https://secure-pgp.wikispaces.com/home ● http://apphysicslinks.weebly.com/teaching-ap-physics.html ● http://www.wikipremed.com/01physicscards.php?card=2 ● https://sites.google.com/site/apphysicsinquiry/home ● https://www.youtube.com/user/bohacekphysics/videos ● http://modelinginstruction.org/ ● http://www.islephysics.net/ ● http://dev.physicslab.org/Default.aspx ● http://ninenet.pbslearningmedia.org/collection/npe11/ ● http://noschese180.wordpress.com/ ● http://www.learner.org/courses/physics/index.html
Student Resources: ● Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson. ● College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson. ● https://phet.colorado.edu/en/simulations/category/physics ● http://hypertextbook.com/

- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Periodic motion – when an object vibrates or oscillates back and forth over the same path with each oscillation taking the same amount of time.

Equilibrium point – any spring has a natural length at which it exerts no force on the mass.

Displacement – the distance 'x' of the mass from the equilibrium point at any moment.

Amplitude – The greatest distance or displacement from the equilibrium point.

Cycle – one complete back and forth motion from an initial point back to the same point.

Simple harmonic motion – any oscillating system where the net restoring force is directly proportional to the negative displacement, or the total mechanical energy of a SHM is proportional to the sqare of the amplitude.

Simple pendulum – a object suspended from the end of a light weight cord where the mass of the cord is ignored.

Resonance - the tendency of a system to oscillate with greater amplitude at some frequencies than at others. Frequencies at which the response amplitude is a relative maximum are known as the system's resonant frequencies.

Mechanical waves – examples are waves on the water or waves on a rope or string.

Transverse waves - If a transverse wave is moving in the positive x-direction, its oscillations are in up and down directions that lie in the y–z plane. Light is an example of a transverse wave. With regard to transverse waves in matter, the displacement of the medium is perpendicular to the direction of propagation of the wave.

Longitudinal waves - also known as "l-waves", are waves in which the displacement of the medium is in the same direction as, or the opposite direction to, the direction of travel of the wave.

Wave speed – the speed the wave crest or any other fixed point on the wave moves forward.

Intensity – 'I' is the power, energy per unit time, transported across the unit area perpendicular to the direction of energy flow.

Interference – when two waves pass through the same area at the same time. The can add together, constructive, or cancel each other out, destructive.

Refraction - the change in direction of a wave due to a change in its transmission medium. Refraction is essentially a surface phenomenon.

Diffraction - the bending of waves around small obstacles and the spreading out of waves beyond small openings.

Content Area: Science	Course: AP Physics 1	UNIT 8: Electrostatics and DC Circuits

Unit Description:	Unit Timeline:
Electrostatic charges and Coulombs Law are the basis for explanation of how DC circuits operate.	2 weeks

DESIRED Results
<u>Transfer Goal</u> - ***Students will be able to independently use their learning to……*** ● Develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines in order to connect concepts in and across domains as it relates to real world applications.

<u>Understandings</u> – ***Students will understand that… (Big Ideas)***

1. Use Coulomb's Law to quantitatively and qualitatively make predictions about the interactions between two point charges.
2. Connect the concepts of gravitational force and electric force to compare similarities and differences between the two forces.
3. Apply conservation of energy concepts and conservation of electric charges using Kirchoff's Laws to various DC circuits to determine various values.

<u>Essential Questions</u>: *Students will keep considering…*

- How can static electricity be used to explain electric phenomena?
- How can the force between two charges be characterized by Newton's Laws?
- How do charges move through conductors?
- How can conservation laws be applied to electric circuits?
- How can we use voltage, current, and resistance to describe electrical function in a circuit?

Students will know…..	Standard	Students Will Be Able to…..	Standard
A collection of particles in which internal interactions change little or not at all, or in which changes in these interactions are irrelevant to the question addressed, can be treated as an object.	1.A.1	The student is able to make claims about natural phenomena based on conservation of electric charge.	**1.B.1.1**
Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.	1.B.1	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.	**1.B.1.2**
There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge.	1.B.2	The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.	**1.B.2.1**
The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.	1.B.3	The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated. [See Science Practices 1.5, 6.1, and 7.2]	1.B.3.1
Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.	3.C.2	The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.	**3.C.2.1**
For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.	5.A.2	The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.	**3.C.2.2**
The change in electric potential in a circuit is the change in potential energy per unit charge.	5.B.3	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.	**5.A.2.1**
Kirchhoff's loop rule describes conservation of energy in electrical circuits.	5.B.9	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).	**5.B.9.1**
Kirchhoff's junction rule describes the conservation of			

electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit.	5.C.3	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 ($\Sigma\Delta V = 0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. 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. 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. 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. 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. <u>Common Core Reading Standards for Grades 11 - 12</u> Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	5.B.9.2 5.B.9.3 **5.C.3.1** **5.C.3.2** **5.C.3.3** RST.1

		Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently. <u>Common Core Writing Standards for Grades 11-12</u> Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and	RST.2 RST.4 RST.7 RST.8 RST.10 WHST.1

		thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create	 WHST.2

		cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).	WHST.4
		Produce writing in which the organization, development, substance, and style are appropriate to task, purpose, and audience.	WHST.7
		Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	WHST.8
		Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.	ISTE.1
		Creativity and innovation. Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.	

		a. Apply existing knowledge to generate new ideas, products, or processes b. Create original works as a means of personal or group expression c. Use models and simulations to explore complex systems and issues d. Identify trends and forecast possibilities Research and information fluency. Students apply digital tools to gather, evaluate, and use information. a. Plan strategies to guide inquiry b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks d. Process data and report results 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. a. Identify and define authentic problems and significant questions for investigation b. Plan and manage activities to develop a solution or complete a project c. Collect and analyze data to identify solutions and/or make informed decisions d. Use multiple processes and diverse perspectives to explore alternative solutions	ISTE.3 ISTE.4

EVIDENCE of LEARNING

Understanding	Standards	Unit Performance Assessment:	R/R Quadrant
1,2,3,4	**1.B.1.1** **1.B.1.2** **1.B.2.1** **3.C.2.1** **3.C.2.2** **5.A.2.1** **5.B.9.1** **5.C.3.1** **5.C.3.2** **5.C.3.3** ISTE.4 RST.2 RST.4 RST.8 RST.10 WHST.1 WHST.2 WHST.4	**Description of Assessment Performance Task(s):** See Appendix - 8.A Unit 8 - Electrostatics and DC Circuits Performance Task **Teacher will assess:** What criteria will be used in each assessment to evaluate attainment of the desired results? 1. Students will demonstrate their ability to relate electrostatic forces and gravitational forces using Coulomb's Law, Newton's Law's and Gravitational forces via calculations, deriving formulas, and answering conceptual questions. Students show their abilities to relate conservation of energy and conservation of charges using Kirchoff's Laws and DC circuits. Ohm's Law will be demonstrated by evaluating various circuit components and determining the values of voltage, ohms, or current in the circuit. **Performance:** **Mastery:** Students will show that they really understand when they… achieve a 80% mastery on the performance task. **Scoring Guide:** See Appendix ______ 8.C Unit 8 - Electrostatic and DC Circuits assessment blueprint template and 8.B Unit 8 - Electrostatic and DC Circuits Performance Task Rubric	C **21 Century** Critical Thinking

SAMPLE LEARNING PLAN

Pre-assessment: Please see Appendix for Unit 8 - 08 Unit 8 - Electrostatics and DC Circuits Pre-Assessment. Includes answer key.

Understanding	Standards	Major Learning Activities: **Activities are designed to prepare students for AP Test items.**	Instructional Strategy:	R/R Quadrant: 21 Century
1	1.B.1.1 1.B.1.2 1.B.2.1 1.B.3.1 ISTE.3 ISTE.4 RST.1 RST.8	1. Activity: Electrostatics ● Students follow the directions of the two online activities to gain experience with electrostatic phenomena while building understanding of electric charges and their interactions in conductors and insulators. Students use sticky tape and a variety of objects to make qualitative observations of the interactions when objects are charged, discharged, and recharged. ● Objective: Students will understand electrostactic phenomena. Appendix Document: 8.D Unit 8 - Electrostatics	Nonlinguistic representation	B Critical Thinking
3	1.B.1.1 1.B.1.2 5.A.2.1 5.C.3.3 ISTE.1 RST.2 RST.7 RST.8 WHST.1 WHST.7 WHST.8	2. Activity: Bulbs and Batteries ● Students working with a partner use wires, light bulbs, and batteries in guided-inquiry tasks that introduce the concepts of electric circuits, series connections, and parallel connections. ● Objective: Students will understand how to make predictions about the brightness of light bulbs in a circuit when some of the bulbs are removed. Appendix Document: 8.E Unit 8 - Bulbs and Batteries	Cues, questions, and advance organizers	A Collaboration
2	1.B.1.1 1.B.1.2 5.A.2.1 5.C.3.3	3. Activity: Ohms Law Lab ● In the first part of this investigation, students work in small groups to design and implement an experiment to	Generating and testing hypotheses Similarities and Differences	C Communication Collaboration Creativity

	ISTE.1 RST.2 RST.7 RST.8 WHST.1 WHST.7 WHST.8	determine the relationship between the current through a resistor and the voltage across the resistor. In the second part of the lab, students test whether the relationship between current and voltage found in the previous experiment is applicable to a light bulb. • Objective: Students will be able to calculate voltage, current, and resistance by using Ohms Law. They will also be able to develop formal arguments for their results along with critiquing the reasoning of other students. Appendix Document: 8.F Unit 8 - Ohms Law Lab		
3	1.E.2.1 3.C.2.1 3.C.2.2 ISTE.1 RST.2 RST.7 RST.8 WHST.1 WHST.7 WHST.8	4. Activity: Resistance and Resistivity Lab • Students work with a partner to investigate the effects of cross- sectional area and length on the current through a roll of Play-Doh. To perform the investigation, students construct a simple circuit and take measurements of the current through rolls of Play-Doh of various dimension. • Objective: Students will be able to create working circuits and make calculations using Ohms law. Appendix Document: 8.G Unit 8 - Resistance and Resistivity Lab	Identifying similarities and differences	C Creativity
3	5.B.9.1 5.B.9.2 5.B.9.3 5.C.3.1 ISTE.1 RST.2 RST.7 RST.8 WHST.1 WHST.7 WHST.8	5. Activity: Circuit Simulation • Students use the Web simulation to construct a variety of series and parallel circuits. They then write descriptions of how the current and voltage work in each combination. Measurements of resistance, current, and potential differences must be included to validate their descriptions. • Objective: Students will be able to compare and contrast parallel and series circuits. Appendix Document: 8.H Unit 8 - Circuit Simulation	Nonlinguistic representations	B Critical Thinking

UNIT RESOURCES

Teacher Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- Newtonian Tasks Inspired by Physics Education Research: nTIPERs, C J Hieggelke, D P Maloney, Steve Kanim
- https://secure-pgp.wikispaces.com/home
- http://apphysicslinks.weebly.com/teaching-ap-physics.html
- http://www.wikipremed.com/01physicscards.php?card=2
- https://sites.google.com/site/apphysicsinquiry/home
- https://www.youtube.com/user/bohacekphysics/videos
- http://modelinginstruction.org/
- http://www.islephysics.net/
- http://dev.physicslab.org/Default.aspx
- http://ninenet.pbslearningmedia.org/collection/npe11/
- http://noschese180.wordpress.com/
- http://www.learner.org/courses/physics/index.html

Student Resources:

- Physics: Principles with Applications, 7/E, Douglas C. Giancoli, Pearson.
- College Physics a Strategic Approach, 3rd E, AP Edition, Knight, Jones, Field, Pearson.
- https://phet.colorado.edu/en/simulations/category/physics
- http://hypertextbook.com/
- https://prettygoodphysics.wikispaces.com/home
- http://www.learnapphysics.com/
- https://www.youtube.com/user/bohacekphysics/videos
- http://www.physicsclassroom.com/
- http://dev.physicslab.org/Default.aspx
- http://www.cyberphysics.co.uk/index.html

Vocabulary:

These are words and definitions students will need to be familiar with to complete the objectives for the unit.

Static electricity - an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric current or electrical discharge.

Law of conservation of electric charge – the net amount of electric charge produced in any process is zero, or charge can neither be created

nor destroyed.
Conductor - an object allowing the flow of electric charge.
Insulator - a material whose internal electric charges do not flow freely, and therefore make it very hard to conduct an electric current.
Elementary charge - fundamental physical constant expressing the naturally occurring unit of electric charge, equal to $1.6021765 \times 10^{-19}$ coulomb.
Coulomb - is a fundamental unit of electrical charge, and is also the SI derived unit of electric charge (symbol: Q or q). It is equal to the charge of approximately 6.241×10^{18} electrons.
Coulomb's Law - the electrical force between two charged objects is directly proportional to the product of the quantity of charge on the objects and inversely proportional to the square of the separation distance between the two objects.
Principle of superposition – if several charges are present, the net force on any one of them will be the vector sum of the forces due to each other.
Electric current – the flow of electrons in a conductor.
Ampere – amount of charge, coulombs, that passes through a conductor at any location during a time interval.
Resistance – impedes the flow of electrons in a wire. It is measured in ohms.
Ohm's Law - the current through a conductor between two points is directly proportional to the potential difference across the two points, $R=V/I$.
Electric power - in watts associated with a complete electric circuit or a circuit component represents the rate at which energy is converted from the electrical energy of the moving charges to some other form, e.g., heat, mechanical energy, or energy stored in electric fields or magnetic fields, $P=IV$.
Series circuit – has only one path or conductor for the electrons to move through.
Parallel circuit – has multiple paths or conductors for the electrons to move through.
Kirchhoff's junction rule – at any junction point, the sum of all the currents entering the junction must equal the sum of all currents leaving the junction.
Kirchhoff's loop rule – the sum of the changes in potential, voltage, around the any closed loop of a circuit must be zero.
Electrical schematic – an electrical diagram is a simplified conventional graphical representation of an electrical circuit.