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|  | AP Physics 1 Curriculum Guide  SCI 525/526  2022-2023 |

<http://grading.dmschools.org>

<http://science.dmschools.org>

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| **Evidence shows the student ...** | **Topic Score** |
| Demonstrates proficiency (AT) in all learning targets and success at Level 4 | 4.0 |
| Demonstrates proficiency (AT) in all learning targets with partial success at Level 4 | 3.5 |
| Demonstrates proficiency (AT) in **all** learning targets | 3.0 |
| Demonstrates proficiency (AT) in **at least half** of the learning targets | 2.5 |
| Demonstrates some success criteria (PT) toward **all** learning targets | 2.0 |
| Demonstrates some success criteria (PT) towards **some** of the learning targets | 1.5 |
| Does not yet meet minimum criteria for the targets. | 1.0 |
| Produces no evidence appropriate to the learning targets at any level | 0 |

**Standards-Referenced Grading Basics**

**Our purpose in collecting a body of evidence is to:**

* Allow teachers to determine a defensible and credible topic score based on a representation of student learning over time.

**Start at Level 3 when determining a topic → score.**

* Clearly communicate where a student’s learning is based on a topic scale to inform instructional decisions and push student growth.
* Show student learning of targets through multiple and varying points of data
* Provide opportunities for feedback between student and teacher.

**Scoring**

A collaborative scoring process is encouraged to align expectations of the scale to artifacts collected. Routine use of a collaborative planning and scoring protocol results in calibration and a collective understanding of evidence of mastery. Enough evidence should be collected to accurately represent a progression of student learning as measured by the topic scale. Teachers look at all available evidence to determine a topic score. All topic scores should be defensible and credible through a body of evidence.

**Guiding Practices of Standards-Referenced Grading**

1. A consistent 4-point grading scale will be used.
2. Student achievement and behavior will be reported separately.
3. Scores will be based on a body of evidence.
4. Achievement will be organized by learning topic and converted to a grade at semester’s end.
5. Students will have multiple opportunities to demonstrate proficiency.
6. Accommodations and modifications will be provided for exceptional learners.

**\*\*\*Only scores of 4, 3.5, 3, 2.5, 2, 1.5, 1, and 0 can be entered as Topic Scores**.

**Multiple Opportunities**

Philosophically, there are two forms of multiple opportunities, both of which require backwards design and intentional planning. One form is opportunities planned by the teacher throughout the unit of study and/or throughout the semester. The other form is reassessment of learning which happens after completing assessment of learning at the end of a unit or chunk of learning.

Students will be allowed multiple opportunities to demonstrate proficiency. Teachers need reliable pieces of evidence to be confident students have a good grasp of the learning topics before deciding a final topic score. To make standards-referenced grading work, the idea of “multiple opportunities” is emphasized. If after these opportunities students still have not mastered Level 3, they may then be afforded the chance to reassess.

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| **AP Physics 1** |
| AP Physics 1: Algebra-based is the equivalent of the first semester of an introductory, algebra-based Physics college course. Because this course is intended to be a yearlong course, teachers have time to foster deeper conceptual understanding through student-centered, inquiry-based instruction. Students have time to master foundational physics principles while engaging in science practices to earn credit or placement.  **AP Physics 1** **– Course Content:**  **Big Idea 1**: Objects and systems have properties such as mass and charge. Systems may have internal structure.  **Big Idea 2**: Fields existing in space can be used to explain interactions.  **Big Idea 3**: The interactions of an object with other objects can be described by forces.  **Big Idea 4**: Interactions between systems can result in changes in those systems.  **Big Idea 5**: Changes that occur as a result of interactions are constrained by conservation laws.  **Big Idea 6**: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.  **AP Physics 1 – Scientific Practices:**  • Use representations and models to communicate scientific phenomena and solve scientific problems • Use mathematics appropriately  • Engage in scientific questioning to extend thinking or to guide investigations • Work with scientific explanations and theories  • Plan and implement data collection strategies in relation to a particular scientific question • Perform data analysis and evaluation of evidence  • Connect and relate knowledge across various scales, concepts, and representations in and across domains.  **AP Physics** **Exam: Format of Assessment – 3 Hours**  **Section I: Multiple Choice | 50 Questions | 90 Minutes | 50% of Exam Score**  • Discrete Items, Items in Sets, and Multi-Select Items (two options are correct)  **Section II: Free Response | 5 Questions | 90 Minutes | 50% of Exam Score**  • Experimental Design (1 question)  • Quantitative/Qualitative Translation (1 question)  • Short Answer (3 questions)  **Link to DMPS Grading Resources:** <http://grading.dmschools.org>  **Link to Course Resources**: <http://science.dmschools.org>  **Link to Course Information @ AP Central:** <http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/2262.html> |

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| Semester 1 Topics | College Board Curriculum Framework Alignment |
| Kinematics:  Constant Velocity | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems. |
| Kinematics: Constant Acceleration | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems. |
| Dynamics: Non-Accelerated Motion | Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.  Big Idea 2: Fields existing in space can be used to explain interactions.  Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems. |
| Dynamics: Accelerated Motion | Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.  Big Idea 2: Fields existing in space can be used to explain interactions.  Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems. |
| Circular Motion | Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.  Big Idea 2: Fields existing in space can be used to explain interactions.  Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems. |
| Momentum & Impulse | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems.  Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. |
| Science Practices | Science Practices 1: Use representations and models to communicate scientific phenomena and solve scientific problems  Science Practices 2: Use mathematics appropriately;  Science Practices 3: Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;  Science Practices 4: Plan and implement data collection strategies in relation to a particular scientific question;  Science Practices 5: Perform data analysis and evaluation of evidence;  Science Practices 7: Connect and relate knowledge across various scales, concepts, and representations in and across domains. |

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| Semester 2 Topics | College Board Curriculum Framework Alignment |
| Energy | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems.  Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. |
| Rotational Motion | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 4: Interactions between systems can result in changes in those systems.  Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. |
| Simple Harmonic Motion | Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. |
| Waves & Sound | Big Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena. |
| Electricity | Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.  Big Idea 3: The interactions of an object with other objects can be described by forces.  Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. |
| Science Practices | Science Practices 1: Use representations and models to communicate scientific phenomena and solve scientific problems  Science Practices 2: Use mathematics appropriately;  Science Practices 3: Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;  Science Practices 4: Plan and implement data collection strategies in relation to a particular scientific question;  Science Practices 5: Perform data analysis and evaluation of evidence;  Science Practices 7: Connect and relate knowledge across various scales, concepts, and representations in and across domains |

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| Kinematics: Constant Velocity |
| **Text and Resources** |
| \*Identify and define: velocity, speed, displacement, magnitude, position  College Physics Text: 1.1-1.6, 2.1-2.3 |

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| **Topic** | **4** | **3** | **2** |
| **Kinematics:**  **Constant Velocity** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  Create and interpret mathematical models for velocity and position for multiple objects and use them to predict the motion of the objects with different starting times. | 3A: Evaluate position vs. time and velocity vs. time graphs for slope, y-intercept, and area for an object moving with a constant velocity.  3B: Evaluate position vs time and velocity vs time graphs for slope, y-intercept, and area for multiple objects moving with a constant velocity.  3C: Analyze a motion graph to create a mathematical model for the velocity and position of an object and use them to predict the motion of the object. | 2A: Create a graph (position vs time and velocity vs time) of an object moving with a constant velocity.  2B: Create a graph (position vs time and velocity vs time) for multiple objects moving with a constant velocity.  2C: Describe the motion of an object traveling at a constant velocity using the kinematics equations.  (Given an equation such as x - 2m = (5m/s) t + 4m, describe the motion of an object.) |

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| Kinematics: Constant Acceleration |
| **Text and Resources** |
| Identify and define: velocity, speed, displacement, magnitude, position, acceleration  College Physics Text: 2.4-2.7, 3.1-3.7 |

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| **Topic** | **4** | **3** | **2** |
| **Kinematics:**  **Constant Acceleration** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  Create and interpret mathematical models for velocity and position for multiple objects and use them to predict the motion of the objects with different starting times or accelerations.  Analyze the motion for a projectile launched at an angle with a total vertical displacement that is not zero. | 3A: Evaluate position vs. time, velocity vs. time, and acceleration vs time graphs for slope, y-intercept, and area for an object moving with a constant acceleration.  3B: Evaluate position vs. time, velocity vs. time, and acceleration vs time graphs for slope, y-intercept, and area for multiple objects moving with a constant acceleration.  3C: Analyze a motion graph to create a mathematical model for the acceleration, velocity and position of an object and use the model to predict the motion of the object.  3D: Analyze the motion for a projectile launched at an angle with a total vertical displacement of zero. | 2A: Create a graph (position vs time, velocity vs time, and acceleration vs time) of an object moving with a constant acceleration.  2B: Create a graph (position vs time, velocity vs time, and acceleration vs time) of multiple objects moving with a constant acceleration.  2C: Describe the motion of an object traveling at a constant acceleration using the kinematics equations.  2D: Analyze the motion for a horizontally launched projectile. |

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| Dynamics: Non-Accelerated Motion |
| **Text and Resources** |
| Determine the relationship between the net force, inertial mass, + acceleration.  Measure gravitational mass and inertial mass, and distinguish between the two experiments.  Determine the relationship between the net force and the vector sum of the individual forces.  \*Identify and define: net force, vector, action-reaction pair, inertial mass, gravitational mass, balanced  College Physics Text: 4.1-4.7 |

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| **Topic** | **4** | **3** | **2** |
| **Dynamics: Non-Accelerated Motion** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  4A: Evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. | 3A: 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.  3B: Construct and analyze explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.  3C: 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. | 2A: Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively to include Fg, Ff, and FN.  2B.1: Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.  2B.2: Describe a force as an interaction between two objects and identify both objects for any force.  2C: Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. |

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| Dynamics: Accelerated Motion |
| **Text and Resources** |
| \*Identify and define: net force, unbalanced, acceleration  College Physics Text: 4.5, 5.1-5.8 |

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| **Topic** | **4** | **3** | **2** |
| **Dynamics: Accelerated Motion** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  4: 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 two dimension (3.B.1.1). | 3A: Apply Newton's second law to analyze the motion of an object when a Net force is applied in one dimension. (4.A.3.1).  3B: Apply a visual or mathematical representation of multiple forces on a single object to determine the net force on and acceleration of the object (i.e. object on an inclined plane, etc.)  3C: Predict the motion of multiple objects 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 (3.B.1.1). | 2A: 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).  2B: Create a visual or mathematical representation of multiple forces on a single object (i.e. object on an inclined plane, etc.)  2C: Express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object (3.B.1.3). |

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| Circular Motion |
| **Text and Resources** |
| Design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments.  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.  Collect and analyze motion data for applied force and determine the relationship between the net force and the vector sum of the individual forces.  Identify and define centripetal force, centripetal acceleration, gravitational field, gravitational force, inertial mass, gravitational mass  College Physics Text: 6.1 – 6.6, 3.8 |

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| **Topic** | **4** | **3** | **2** |
| **Circular Motion** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*    Evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. | 3A: 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.    3B: Use Newton's law of gravitation to calculate the gravitational force between two objects.  3C: Analyze a system where the net force causes circular motion. | 2A: Apply g = GM/r2 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.  2B: 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.  2C: Create and use free-body diagrams to analyze physical situations using net force equations to solve problems with motion qualitatively and quantitatively. |

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| Momentum & Impulse |
| **Text and Resources** |
| Perform analysis force-time graph and predict the change in momentum.  Design plan to collect and analyze data for change in momentum, average force and time.  \*Identify and define: conservation of momentum, impulse, momentum  College Physics Text: 9.1-9.6 |

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| **Topic** | **4** | **3** | **2** |
| **Momentum & Impulses** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.* | 3A: Create and analyze a mathematical relationship between the direction of the force acting on an object and the change in momentum caused by that force.  3B: Calculate the change in linear momentum of a two-object system with constant mass in a 2D collision from a representation of the system (data, graphs, etc.)  3B: Apply the Law of Conservation of Momentum to determine the motion of objects after a collision. | 2A: 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.  2B: 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.)  2B: Calculate the momentum of each object before a collision. |

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| Science Practices |
| **Text and Resources** |
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| **Topic** | **4** | **3** | **2** |
| **Scientific Practices** | *In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal.*   * Engage in scientific questioning to extend thinking or guide investigations within the context of an AP course (SP.3).   **OR**   * Connect and relate knowledge across various scales, concepts, and representations in and across domains (SP.7). | Apply scientific practices to physics.   * Use representations and models (graphs, diagrams, tables, charts) to communicate scientific phenomena and solve scientific problems (SP.1). * Use mathematics appropriately (SP.2). * Implement data collection strategies (SP.4) and perform data analysis and evaluate evidence (SP.5). * Support conclusions using experimental evidence and scientific reasoning. | A level 2 in scientific practices fails to meet the learning goal in two areas:   * Use representations and models to communicate scientific phenomena and solve scientific problems (SP.1). * Use mathematics appropriately (SP.2.) * Implement data collection strategies (SP.4) and perform data analysis and evaluate evidence (SP.5). * Support conclusions using experimental evidence and scientific reasoning. |

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| Energy |
| **Text and Resources** |
| Design experiment and analyze data to examine how a force does work through a distance.  Design an experiment and analyze graph for area under a force-distance curve to determine the work done  Design an experimental application for conservation of linear momentum, predict an outcome, analyze data generated and evaluate the match between the prediction and the outcome.  Test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically.  \*Identify and define: potential energy gravitationally, kinetic energy, potential energy elastically, elastic and inelastic collisions, work, thermal energy, conservation of energy, conservation of momentum  College Physics Text: 9.5, 9.6, 10.1-10.8 |

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| **Topic** | **4** | **3** | **2** |
| **Energy** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.* | 3A: Analyze the energy in the system to calculate changes in energy when work is not done on or by the system.  3B: Analyze the energy in the system to calculate changes in energy when energy is added to the system through work or when the system does work on the surroundings.  3C: Analyze a force vs. displacement graph for changes in energy.  3D: Analyze the energy in a collision to determine if the collision is elastic or inelastic and justify the answer. | 2A: Define the system and predict changes in energy (K, Ug, Us, and Eth) when work is not done on or by the system.  2B: Define the system and predict changes in energy (K, Ug, Us, and Eth) when energy is added to the system through work or when the system does work on the surroundings.  2C: Create a force vs. displacement graph from a description, data, or diagram of the system.  2D: Identify when energy is conserved in a collision. |

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| Rotational Motion |
| **Text and Resources** |
| Design an experiment and analyze data testing a question about torques in a balanced rigid system.  Plan and analyze the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis.  Establish that torque, angular velocity, acceleration, and momentum can be predicted if variables are treated as being CW or CCW.  Determine change in angular momentum of a system and relate it to interactions with other objects and systems.  Test relationship between the change in angular momentum & average torque applied to the system and the time interval during which the torque is exerted.  Identify and define: rotational inertia, torque, angular momentum, angular displacement, angular velocity, angular acceleration, static equilibrium, rotational kinetic energy  College Physics Text: 7.1-7.7, 8.1-8.2, 9.7 |

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| **Topic** | **4** | **3** | **2** |
| **Rotational Motion** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  4:Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum. | 3A: Evaluate the torques and forces for a system that is in static equilibrium.  3B: Evaluate the torques and forces for a system that is not in static equilibrium, and the interaction between rotational inertia and angular velocity.  3C. Analyze a situation in which angular momentum changes due to interaction with other objects or systems.  3D: Analyze the relationship between gravitational potential energy, linear kinetic energy, and rotational kinetic energy for a rolling object. | 2A: Calculate torques on a two-dimensional system in static equilibrium by examining a representation or model (such as a diagram or physical construction).  2B.1: Identify the factors that affect the rotational inertia of the objects in a system.  2B.2: Evaluate and determine the net torque for a system.  2C.1: 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.  2C.2: Calculate values for angular momentum, torque and time.  2D.1: Analyze the relationship between rotational inertia, mass, and radius for objects of different shapes.  2D.2: Calculate the rotational kinetic energy for an object when the rotational inertia is known. |

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| Simple Harmonic Motion |
| **Text and Resources** |
| Plan & collect data to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force.  Analyze data to identify qualitative/ quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) to determine the value of an unknown.  Identify and define: force, displacement, velocity, acceleration, period of motion, frequency, spring constant, string length, and mass  College Physics Text: 14.1 – 14.7, 8.3 |

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| **Topic** | **4** | **3** | **2** |
| **SHM** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.*  4: 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 | 3A. Analyze data to create a model that describes the quantitative relationships for pendulum motion.  3B. Analyze data to create a model that describes the quantitative relationships for an object connected to an oscillating spring.    3C. Utilize a model for energy in a system to analyze gravitational potential energy and kinetic energy conversions within the system for pendulum motion.  3D. Utilize a model for energy in a system to analyze the internal potential energy and kinetic energy conversions within the system for an oscillating spring. | 2A. Predict which properties determine the motion a pendulum.  2B. Predict which properties determine the motion of an oscillating spring.  2C. Make qualitative and/or quantitative predictions about everyday examples of the energy transfer in pendulum motion.  2D. Make qualitative and/or quantitative predictions about everyday examples of the energy transfer in an oscillating spring. |

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| Waves & Sound |
| **Text and Resources** |
| Analyze data & identify patterns for a wave (polarized) and explain that the wave must have a vibration perpendicular to the direction of the energy propagation.  Determine relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples.  Design and analyze data illustrating the superposition of mechanical waves (only for wave pulses or standing waves)  Collecting data to determine amplitude variations when two or more traveling waves or wave pulses interact in a given medium.  Analyze the relationship among variables responsible for establishing standing waves on a string or in a column of air.  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 [see Science Practices 2.1, 3.2, and 4.2].  College Physics Text: 15.1-15.7, 16.1-16.7 |

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| **Topic** | **4** | **3** | **2** |
| **Waves & Sound**  Doppler Effect, amplitude, wavelength, frequency, node, antinode, beats, free boundary, fixed boundary, superposition, interference, constructive, destructive, standing waves, transverse, longitudinal, medium | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.* | 3A. Explain and or predict how the properties of sound are changed based on the physical properties of amplitude, frequency, wavelength and medium and relate the concepts to everyday examples.  3B. Analyze a system for wavelengths and frequencies of standing waves based on boundary conditions and the length of the region within which the wave is confined.    3C: 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 (including beats).[SP5.1] | 2A.1: Use a model to explain transverse and longitudinal waves.  2A.2: Use a model of a periodic mechanical wave to determine the period, frequency, wavelength, and amplitude of the wave and describe how any change would modify the wave representation.  2B.1: Predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes.[SP 6.4]  2B.2: Describe representations and models of situations in which standing waves result from the addition of incident and reflected waves confined to a region.[SP 1.2]  2C.1: Use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of the pulses.  2C.2: Use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats.[SP 1.2] |

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| Electricity |
| **Text and Resources** |
| Investigate an electrical circuit with one or more resistors and analyze conservation of electric charge.  Apply conservation of energy to an experiment demonstrates Kirchhoff's loop rule.  (ΣV = 0) in a circuit with a battery and resistors either in series or in, at most, one pair of parallel branches.  Identify and define: voltage, current, resistance, potential difference, point charge, series circuit, parallel circuit, complex circuit, Ohm’s Law, Coulomb’s Law, junction rule, loop rule  College Physics Text: 20.1-20.3, 22.1-22.6, 23.1-23.5 |

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| **Topic** | **4** | **3** | **2** |
| **Electricity** | *In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal.* | 3A: Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges  3B: 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.  3C: 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. | 2A1: Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.  2B1: 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.  2B2: Use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit.  2C: 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). |

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| **SRG Scale Score** | **Topic:**  **AP-Style Assessments** | **AP Exam**  **Score Conversion** |
| **4** | In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal. | **90-100%** |
| **3.5** | Student’s performance reflects exceptional facility with **some**, but not all Level 4 learning targets. | **80-89%** |
| **3**  **Learning Goal** | Student’s performance reflects success on **all Level 3** learning targets. | **70-79%** |
| **2.5** | Student’s performance reflects success on **some**, but not all, Level 3 learning targets | **60-69%** |
| **2** | Student’s performance reflects success on **all Level 2** learning targets. | **50-59%** |
| **1.5** | Student’s performance reflects success on **some** but not all Level 2 learning targets | **40-49%** |
| **1** | Student’s performance reflects insufficient progress towards foundational skills and knowledge. | **20-39%** |