# AP Physics 1

**TEXTBOOK**

Knight, Randall D., Jones Brian, and Field, Stuart. 2015. *College Physics: A Strategic Approach*. 3rd edition. Pearson. San Francisco.

**TEACHING RESOURCES**

Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. *College Physics.* San Francisco, CA: Pearson, 2014.

Hieggelke, Curtis, David Maloney, and Stephen Kanim. *Newtonian Tasks Inspired by Physics Education Research: nTIPERs.* Upper Saddle River, NJ: Pearson, 2012.

**INSTRUCTIONAL STRATEGIES**

The AP Physics 1 course is conducted using inquiry-based instructional strategies that focus on experimentation to develop students' conceptual understanding of physics principles. The students begin studying a topic by making observations and discovering patterns of natural phenomena. The next steps involve developing, testing, and applying models. Throughout the course, the students construct and use multiple representations of physical processes, solve multi-step problems, design investigations, and reflect on knowledge construction through self-assessment rubrics.

In most labs, the students use probeware technology in data acquisition. In the classroom, they use calculators and digital devices for interactive simulations, Physlet-based exercises, collaborative activities, direct measurement videos, and formative assessments.

**COURSE CONTENT**

*Big Ideas*

The course content for AP Physics 1 stems from 6 Big Ideas. All classroom activities and learning goals correlate to at least one Big Idea.

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.

*Topics Covered*

1. Kinematics (Big Idea 3)
    a. Vectors/Scalars
    b. One Dimensional Motion (including graphing position, velocity, and acceleration)
    c. Two Dimensional Motion
2. Dynamics (Big Ideas 1, 2, 3, and 4) [CR2b]
    a. Newton's Laws of Motion and Forces
3. Universal Law of Gravitation (Big Ideas 1, 2, 3, and 4)
    a. Circular Motion
4. Simple Harmonic Motion (Big Ideas 3 and 5)
    a. Simple Pendulums
    b. Mass-Spring Oscillators
5. Momentum (Big Ideas 3, 4, and 5)
    a. Impulse and Momentum
    b. The Law of Conservation of Momentum
6. Energy (Big Ideas 3, 4, and 5)
    a. Work
    b. Energy
    c. Conservation of Energy
    d. Power
7. Rotation (Big Ideas 3, 4, and 5)
    a. Rotational Kinematics
    b. Rotational Energy
    c. Torque and Rotational Dynamics
    d. Angular Momentum
    e. Conservation of Angular Momentum
8. Electrostatics (Big Ideas 1, 3, and 5)
    a. Electric Charge
    b. The Law of Conservation of Electric Charge
    c. Electrostatic Forces
9. Circuits (Big Ideas 1 and 5)
    a. Ohm's Law
    b. Kirchhoff's Laws
    c. Simple DC Circuits
10. Mechanical Waves and Sound (Big Idea 6)

**LABORATORY PRACTICES AND SCIENCE PRACTICES**

The AP Physics 1 course devotes over 25% of the time to laboratory investigations. The laboratory component of the course allows the students to demonstrate the seven science practices through a variety of investigations in all of the foundational principles. The students use guided–inquiry (GI) or open–inquiry (OI) in the design of their laboratory investigations. Some labs focus on investigating a physical phenomenon without having expectations of its outcomes. In other experiments, the student has an expectation of its

outcome based on concepts constructed from prior experiences. In application experiments, the students use acquired physics principles to address practical problems. Students also investigate topic-related questions that are formulated through student designed/selected procedures.

All investigations are reported in a laboratory journal.Throughout the semester students will complete several formal lab reports that will be constructed from data, observations, and analysis recorded in their laboratory journal. These formal lab reports will consist of the following:

1. Research Question
2. Step-by-step procedures
3. Data collected
4. Data analysis, including thorough graph analysis.
5. Discussion of analysis, uncertainty, and error.
6. Conclusion containing a claim that answers the research question, citing evidence to support that claim, and reasoning linking the evidence to the claim.

All investigative (as opposed to practicum) labs will conclude with a peer-review session. Students will display their data, analysis, and evidence supporting a claim that answers the research question on large whiteboards. Through various activities, students will discuss their analysis and claims with each other and, as a class, come to a consensus on a claim that answers the research question. Through this process, students are expected to support all claims with evidence and observations obtained through the lab.

For practicum laboratory investigations, students will work in small groups to make evidence-based predictions by applying principles discovered and refined through the investigative labs and classroom activities.

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| UNIT 1. KINEMATICS | 1. Meeting Point<br>To predict where two battery-powered cars will collide if they are released from opposite ends of the lab table at different times.<br>Science Practices 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2<br><br>2. Match the Graph (GI)<br>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, velocity, and acceleration versus time.<br>Science Practices 1.2, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |

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| | 3. Free-Fall Practicum<br>Students will design an experiment using a tennis ball and stopwatch to determine the height of the football stadium bleachers.<br>Science Practices 1.4, 1.5, 2.1, 2.2, 4.1, 4.2, 4.3, 5.3, 6.1, 7.2<br><br>4. Vector Addition (GI) [CR6b]<br>To determine the value of a resultant of several vectors, and then compare that value to the values obtained through graphical and analytical methods.<br>Science Practices 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>5. Shoot the Target (GI) [CR6b]<br>To determine the initial velocity of a projectile, the angle at which the maximum range can be attained, and predict where the projectile will land.<br>Science Practices 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>6. Chase Scenario (GI) [CR6b]<br>Lab Practicum: Students use a battery cart and a fan cart to recreate a chase scenario (police-thief) to predict the position where the 'thief' will be caught and the final speeds of both cars.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
| UNIT 2. DYNAMICS [CR6a] | 7. Inertial and Gravitational Mass (GI) [CR6b]<br>To determine the difference (if any) between inertial mass and gravitational mass.<br>Science Practices 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>8. Forces Inventory (GI) [CR6b]<br>Qualitative and quantitative investigation on a variety of interactions between objects.<br>Science Practices 1,1, 1.4, 1.5, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2<br><br>9. Static Equilibrium Challenge<br>To determine the mass of a hanging object in a setup with three strings at various angles.<br>Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |

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| | 10. Newton's Second Law (OI) [CR6b]<br>To determine the variation of 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.<br>Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2<br>11. Coefficient of Friction (GI) [CR6b]<br>To determine the maximum coefficient of static friction between a mass and a wooden plank.<br>Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>12. Atwood's Machine (GI) [CR6b]<br>To determine the acceleration of a hanging mass and the tension in the string.<br>Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
| UNIT 3. CIRCULAR MOTION AND GRAVITATION [CR6a] | 13. Flying Toy (GI) [CR6b]<br>To determine the tension in the string and the centripetal acceleration of the flying toy.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
| UNIT 4. ENERGY [CR6a] | 14. Roller Coaster Investigation (GI) [CR6b]<br>To design a simple roller coaster using provided materials to test whether the total energy of the system is conserved if there are no external forces exerted on it by other objects.<br>Science Practices 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.2, 6.4, 7.2<br><br>15. Work Done in Stretching a Spring (GI) [CR6b]<br>To determine the work done on the spring from force-versus-distance graph of the collected data.<br>Science Practices 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>16. Energy and Non-Conservative Forces (GI) [CR6b]<br>To determine the energy dissipated by friction of a system consisting of a modified Atwood's machine.<br>Science Practices 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 6.5, 7.2 |

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| UNIT 5. MOMENTUM [CR6a] | 17. Bumper Design (GI) [CR6b]<br>To design a paper bumper 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.<br>Science Practices 1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2<br><br>18. Impulse and Change in Momentum (GI) [CR6b]<br>To measure the change in momentum of a dynamics cart and compare it to the impulse received.<br>Science Practices 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2<br><br>19. Elastic and Inelastic Collisions (OI) [CR6b]<br>To investigate conservation of momentum and conservation of energy using a ballistic pendulum to determine the type of collision.<br>Science Practices 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2<br><br>20. Forensic Investigation (OI) [CR6b]<br>Lab Practicum: Apply principles of conservation of energy, conservation of momentum, the work-energy theorem, and a linear model of friction to find the coefficient of kinetic friction.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
| UNIT 6. SIMPLE HARMONIC MOTION [CR6a] | 21. Finding the Spring Constant (GI) [CR6b]<br>To design two independent experiments to determine the spring constants of various springs of equal length.<br>Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>22. Graphs of an Oscillating System (GI) [CR6b]<br>To analyze graphs of position, velocity, and acceleration versus time for an oscillating system to determine how velocity and acceleration vary at the equilibrium position and at the endpoints.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2<br><br>23. Simple Pendulum Investigation (GI) [CR6b]<br>To investigate the factors that affect the period of a simple pendulum and test whether the period is proportional to the pendulum's |

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| | length, the square of its length, or the square root of its length.<br>Science Practices 1.2, 1.4, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
| UNIT 7. ROTATIONAL MOTION [CR6a] | 24. Torque and the Human Arm (OI) [CR6b]<br>To design and build an apparatus that replicates the forearm and biceps muscle system to determine the biceps tension when holding an object in a lifted position.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.1, 7.2<br><br>25. Rotational Inertia (GI) [CR6b]<br>To determine the rotational inertia of a cylinder from the slope of a graph of an applied torque versus angular acceleration.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2<br><br>26. Conservation of Angular Momentum (GI) [CR6b]<br>To investigate how the angular momentum of a rotating system responds to changes in the rotational inertia.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
| UNIT 8. MECHANICAL WAVES [CR6a] | 27. Mechanical Waves (GI) [CR6b]<br>To model the two types of mechanical waves with a spring toy to test whether or not these characteristics affect the speed of a pulse: frequency, wavelength, and amplitude.<br>Science Practices 1.2, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2<br><br>28. Speed of Sound (GI) [CR6b]<br>Design two different procedures to determine the speed of sound in air.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>29. Wave Boundary Behavior (GI) [CR6b]<br>To compare what happens to the phase of a transverse wave on a spring toy when a pulse is reflected from a boundary and when it is reflected and transmitted from various boundaries (spring to string).<br>Science Practices 1.4, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.4, 7.2<br><br>30. Standing Waves (GI) [CR6b]<br>Given a specified tension, students predict the length of the string necessary to generate the first two harmonics of a standing wave on the string. Then they perform the experiment and compare the |

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| | outcome with their prediction.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
| UNIT 9.<br>ELECTROSTATICS<br>[CR6a] | 31. Static Electricity Interactions (GI) [CR6b]<br>Students use sticky tape and a variety of objects to make qualitative observations of the interactions when objects are charged, discharged, and recharged.<br>Science Practices 1.2, 3.1, 4.1, 4.2, 5.1, 6.2, 7.2 |
| UNIT 10.<br>DC CIRCUITS<br>[CR6a] | 33. Brightness Investigation (GI) [CR6b]<br>To make predictions about the brightness of light bulbs in a variety of series and parallel circuits when some of the bulbs are removed.<br>Science Practices 1.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2<br><br>34. Voltage and Current (GI) [CR6b]<br>To determine the relationship between the current through a resistor and the voltage across the resistor.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2<br><br>35. Resistance and Resistivity (GI) [CR6b]<br>To investigate the effects of cross-sectional area and length on the flow of current through a roll of Play-Doh.<br>Science Practices 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1,5.3, 6.1, 6.4, 7.2<br><br>36. Series and Parallel Circuits (GI) [CR6b]<br>To investigate the behavior of resistors in series, parallel, and series-parallel circuits. The lab should include measurements of voltage and current.<br>Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2 |