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Physics						
(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:						
(A) demonstrate safe practices during field and laboratory investigations; and	√	√	√	√		
(B) make wise choices in the use and conservation of resources and the disposal or recycling of materials.				√		
(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:					• 1999 APPHY-B question #6 (Optics lab question) • 1999 APPHY-C Mech question #1 (Ballistic pendulum lab question) • 2000 APPHY-B question #6 (Specific heat lab question) • 2000 APPHY-C Mech question #1 (Pendulum lab question) • 2001 APPHY-B question #5 (Resistor used as a thermometer) • 2001 APPHY-C EM question #2 (Potential vs time experiment) • 2002 APPHY-B question #6 (Spring, fluid displacement lab question) • 2002 APPHY-C Mech question #3 (Potential energy, force, and displacement)	Frequent laboratory experiences (40% minimum); inquiry labs encouraged once skills are mastered.
(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and	√	√	√	√		

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selecting equipment and technology;						
(B) make quantitative observations and measurements with precision;	√	√	√	√		
(C) organize, analyze, evaluate, make inferences, and predict trends from data; and	√	√	√	√		Should have opportunities to produce hand-written and computer generated graphs. This should include error analysis (sources of error, predicting results based on error scenarios.
(D) communicate valid conclusions;	√	√	√	√		
(E) graph data to observe and identify relationships between variables; and	√	√	√	√		
(F) read the scale on scientific instruments with precision.	√	√	√	√	• The students should be able to effectively use basic scientific instruments such as scales, rulers, calipers, protractors, ammeters, voltmeters, a graphing calculator, and various computer-interfacing probes and software.	
(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:						
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	√					Students should analyze error in their own experiments.

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(B) express laws symbolically and employ mathematical procedures including vector addition and right-triangle geometry to solve physical problems;			√		• 1999 APPHY-C Mech question #1 (Angle of a pendulum) • 1999 APPHY-C EM question #3 (Ring of charge) • 2000 APPHY-B question #2 (Blocks and pulley) • 2000 APPHY-C EM question #2 (Forces on charges in a triangle) • 2001 APPHY-B questions #2, 3, 4 (Momentum vectors, electric field and force vectors, ray optics geometry) • 2001 APPHY-C EM question #1 (Electric field vectors) • 2002 APPHY-C EM questions #1, 3 (Electric field vector, magnetic field vector) • Vector Hunt lab using displacement vectors to navigate around a classroom or campus* • Vector Addition using strings and a force table	Pre-AP* students should become familiar with the sine, cosine, and tangent relationships as they apply to vectors such as displacements, velocities, and forces.
(C) evaluate the impact of research on scientific thought, society, and the environment;				√		
(D) describe the connection between physics and future careers; and						
(E) research and describe the history of physics and contributions of scientists.			√			
(4) Science concepts. The student knows the laws governing motion. The student is expected to:						

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(A) generate and interpret graphs describing motion including the use of real-time technology;			√		• 2000 APPHY-B question #1 (Velocity vs time graph) • 2001 APPHY-C Mech question #1 (Force probe and motion detector) • 2002 APPHY-B question #2 (Potential energy vs displacement graph) • 2002 APPHY-C Mech question #3 (Potential energy vs. displacement graph) • Use Vernier or Pasco motion detectors and software, students can walk or set up ramps and carts to match given motion graphs.*	Plot motion graphs by hand on graph paper and use technology such as motion detectors or sonic rangers which plot *d vs t*, *v vs t*, and *a vs t* graphs on a computer or graphing calculator screen.
(B) analyze examples of uniform and accelerated motion including linear, projectile, and circular;			√		• 1999 APPHY-B question #5 (Coin on a turntable) • 2001 APPHY-B questions #1, 2 (Ball in a vertical circle, projectile motion) • Free Falling Washers lab* • Projectile motion labs using dart guns or a ball projected from a ramp* • Circular motion labs using a stopper on the end of a string which passes through a tube and is swung around in a circle*	Distinguish between uniform (constant) velocity and uniform acceleration; Identify an accelerating object whether it is speeding up, slowing down, or changing direction. Apply vector analysis to velocity and acceleration.
(C) demonstrate the effects of forces on the motion of objects;			√		• 1999 APPHY-B question #1 (Force and motion of a Mars rover) • 2000 APPHY-C Mech question #2 (Falling object) • 2002 APPHY-B question #1 (Rocket thrusting upward)	Students should recognize the difference between force and net force, that an object in equilibrium has zero net force acting on it, and that the application of a net force

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					• 2002 APPHY-C Mech question #1 (Car crashing into an object) • Study forces using force probes and accelerometers, as well as traditional labs*	changes the motion of an object. Apply Newton's 3 laws of motion.
(D) develop and interpret a free-body diagram for force analysis; and			√		• 2000 APPHY-B question #2 (Blocks and pulley on an incline) • 2000 APPHY-C Mech question #2 (Falling object) • Force Table lab	Students should recognize that "free-body diagram" is a diagram of all the forces acting on an object. Apply vector analysis to forces.
(E) identify and describe motion relative to different frames of reference.			√			Distinguish between inertial (constant velocity) frames of reference and non-inertial (accelerating) frames
(5) Science concepts. The student knows that changes occur within a physical system and recognizes that energy and momentum are conserved. The student is expected to:					• 1999 APPHY-B question #3 (Cart rolling down a ramp) • 1999 APPHY-C Mech question #1 (Ballistic pendulum) • 2001 APPHY-B question #2 (Pool balls colliding) • 2002 APPHY-B question #2, 7 (Potential energy graph, Photon-electron collision) • 2002 APPHY-C Mech questions #1, 2, 3 (Car crash, cart and spring collision, potential energy vs. displacement graph)	

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(A) interpret evidence for the work-energy theorem;		√	√			The work done on a system changes an equal amount of the energy of that system.
(B) observe and describe examples of kinetic and potential energy and their transformations;	√	√	√	√	• Investigate energy transformations from potential energy to kinetic energy and energy lost to heat, such as pendulum energy*, a mass on a spring, and energy of a cart rolling down a ramp*. • Design a model of a roller coaster, calculating potential and kinetic energy, and energy lost at each point along the track.*	Apply conservation of energy to free fall, objects moving down ramps, mass on a spring, and a swinging pendulum.
(C) calculate the mechanical energy and momentum in a physical system such as billiards, cars, and trains; and			√			
(D) demonstrate the conservation of energy and momentum.			√		• Conservation of energy and momentum of gliders on an air track or Pasco carts on a metal track using photogates*	Students should take data on inelastic and elastic collisions, and analyze the total momentum and energy before and after the collisions
(6) Science concepts. The student knows forces in nature. The student is expected to:						
(A) identify the influence of mass and distance on gravitational forces;			√		• 2001 APPHY-C Mech question #2	Students should know and apply Newton's law of universal gravitation, and that the gravitational force is an example of a centripetal force for a

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						satellite in a circular orbit.
(B) research and describe the historical development of the concepts of gravitational, electrical, and magnetic force;			√		• 2001 APPHY-C Mech question #2	Students should recognize that the gravitational, electrical, and magnetic forces are all inverse square laws.
(C) identify and analyze the influences of charge and distance on electric forces;			√		• 1999 APPHY-C EM questions #1, 3 (Sphere and ring of charge) • 2000 APPHY-C EM questions #2, 3 (Charge triangle and charged cylindrical capacitor) • 2001 APPHY-B question #3 (Charge and electric field) • 2001 APPHY-C EM question #1 (Charge and electric field) • 2002 APPHY-C EM question #1 (Charged ring and electric field) • Electric Field Mapping lab, using conducting paper, conducting ink, and a voltage probe	Coulomb's law relates the product of the two charges to the square of the distance between them, and follows the same basic form as Newton's law of universal gravitation. Pre-AP students should also have some familiarity with electric field and electric potential difference

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(D) demonstrate the relationship between electricity and magnetism;			√		• 1999 APPHY-B question #3 (Motional emf and electromagnetic induction) • 1999 APPHY-C EM question #2 (Electromagnetic induction) • 2000 APPHY-B question #7 (Charge moving through a magnetic field) • 2000 APPHY-C EM questions #1, 3 (Inductor circuit and current producing a magnetic field) • 2001 APPHY-C EM question #3 (Magnetic field due to a current-carrying wire) • 2002 APPHY-B question #5 (Charge in a magnetic field) • 2002 APPHY-C EM question #3 (Magnetic field through a loop) • Investigate magnetic fields of various magnets using a Vernier or Pasco magnetic field probe • Magnetic Effect of Current lab, using a compass in the center of a current loop to find the relationship between magnetic field and current* • Demonstrate electromagnetic induction using a magnet, a coil of wire, and a galvanometer	Pre-AP students should recognize that magnetic fields are produced by moving charge, including current flow through a wire, and that moving charges experience a force in a magnetic field. Apply the right-hand rule to determine the direction of magnetic forces and fields. Also, a changing magnetic field can generate a voltage in a wire by electromagnetic induction.

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(E) design and analyze electric circuits; and			√		• 2000 APPHY-B question #3 (Resistance-Capacitance circuit) • 2000 APPHY-C EM question #1 (Resistance-capacitance-inductor circuit) • 2001 APPHY-B question #5 (Resistor used as a thermometer) • 2001 APPHY-C EM question #2 (Voltage vs time graph for a capacitor) • 2002 APPHY-B question #3 (Light bulbs in a circuit) • 2002 APPHY-C EM question #2 (Resistance-Capacitance circuit) • Investigate current, voltage, and resistance in series and parallel circuits using ammeters and voltmeters* • Place light bulbs in various circuits and predict brightnesses when bulbs are added or removed* • Design a lab practical for each individual student	Pre-AP students should understand the concepts of voltage, current, and resistance. Apply Ohm's law to series and parallel circuits. Students should be given the opportunity to spend a significant amount of time in this unit doing lab activities with batteries, power supplies, wires, light bulbs and other resistors, and ammeters and voltmeters.
(F) identify examples of electrical and magnetic forces in everyday life.			√		• 1999 APPHY-B question #2 (Electron beam through electric and magnetic fields) • Build an electric motor using a battery, paper clips, a loop of wire, and a disk magnet. • Demonstrate forces on charges in a magnetic field by placing a magnet near a	

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					cathode ray tube or old computer or television screen.	
(7) Science concepts. The student knows the laws of thermodynamics. The student is expected to:					• 1999 APPHY-B question #7 (PV diagram for an ideal gas) • 2000 APPHY-B question #6 (Specific heat lab question) • 2001 APPHY-B questions #5, 6 (Resistor used as a thermometer, pressure and volume of a gas in a cylinder) • 1999 APCHEM question #6 (Entropy, enthalpy, and free energy) • 2000 APCHEM question #6 (Entropy, enthalpy, free energy and kinetics) • 2001 APCHEM question #2 (Entropy, enthalpy, free energy, and bond energy) • 2002 APCHEM question #5 (Molar heat of neutralization lab question) • 2002 APCHEM question #8 (Entropy and enthalpy) • Calorimetry lab showing the heat lost by one system is gained by another	Pre-AP students should recognize that the first law of thermodynamics is an example of conservation of energy, and the second law of thermodynamics is the law of entropy.
(A) analyze and explain everyday examples that illustrate the laws of thermodynamics; and		√	√	√		
(B) evaluate different methods of heat energy transfer that result in an increasing amount of disorder;			√			Students should be able to distinguish between heat transfer by conduction, convection, and radiation.

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(8) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:					• 1999 APPHY-B question #6 (Optics lab question) • 2000 APPHY-B question #4 (Light through a thin film) • 2001 APPHY-B question #4 (Index of refraction of a material) • 2002 APPHY-B question #4 (Light passing through a lens)	
(A) examine and describe a variety of waves propagated in various types of media and describe wave characteristics such as velocity, frequency, amplitude, and behaviors such as reflection, refraction, and interference;		√	√		• Mechanical waves lab including waves in a spring* and waves in a ripple tank.*	
(B) identify the characteristics and behaviors of sound and electromagnetic waves; and	√	√	√		• Produce and study various sound waves using a Vernier or Pasco microphone and analysis software • Measure the speed of sound* • Light labs including reflection from plane* and curved mirrors, refraction and Snell's law,* images formed by convex* and concave lenses, and interference of light through a diffraction grating*	In APBIO, this is related to absorption of light in photosynthesis.
(C) interpret the role of wave characteristics and behaviors found in medicinal and industrial applications.			√			For example, ultrasound
(9) Science concepts. The student knows simple examples of quantum physics. The student is expected to:						Pre-AP students should know that the word "quantum" indicates the smallest particle of a quantity, such as an

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						electron (charge) or photon (light).
(A) describe the photoelectric effect; and		√	√		• 2000 APPHY-B question #5 (Photoelectric effect) • 2002 APPHY-B question #7 (Photon-electron collision) • Use photocells or light probes to demonstrate the operation of devices which operate on the principle of the photoelectric effect, such as solar calculators, video cameras and automatic doors	Students should recognize that light has a dual nature: waves and photons.
(B) explain the line spectra from different gas-discharge tubes.		√	√		• 1999 APCHEM question #2 (Atomic structure w/ bond energy and line spectra) • Demonstrate the spectra emitted by excited gases using hydrogen, helium, neon, and other discharge tubes and diffraction gratings or spectroscopes.	Students should relate line spectra to the transition of electrons in gas atoms from higher energy levels to lower energy levels.