INDIAN HILL EXEMPTED VILLAGE SCHOOL DISTRICT
AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Newton's Laws of Motion

What causes objects to move?
What factors influence the motion of an object?
How can the motion of an object be predicted?
The learner will analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces.
The learner will calculate, for a body moving in one direction, the velocity change that results when a constant force, F, acts over a specified time interval.
The learner will determine, for a body moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the body.
The learner will draw a well-labeled diagram showing all real forces that act on the body.
The learner will write down the vector equation that results from applying Newton's Second Law to the body, and take components of this equation along appropriate axes.
The learner will determine the magnitude and direction of the net force, or of the forces that make up the net force for objects moving up or down with constant acceleration; or objects moving in a horizontal or vertical circle.
The learner will write down the relation between the normal and frictional forces on a surface.
The learner will analyze situations in which a body slides down a rough inclined plane or is pulled or pushed across a rough surface.
The learner will analyze static situations involving friction to determine under what circumstances a body will start to slip, or to calculate the magnitude of the force of static friction.
The learner will identify the body on which the reaction force acts and state the magnitude and direction of this force.
The learner will apply Newton's Third Law in analyzing the force of contact between two bodies that accelerate together along a horizontal or vertical line, or between two surfaces that slide across one another.
The learner will analyze the motion of a system of two bodies joined by a string, recognizing that tension is constant.

Learning Targets:

• Standard 3 Physical Sciences

• Indicator 3.D.5 Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.

• Organizer   Historical Perspectives and Scientific Revolutions

• Indicator 3.E.14 Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., nuclear energy, quantum theory, theory of relativity).

• Indicator 3.E.15 Describe concepts/ideas in physical sciences that have important, long-lasting effects on science and society (e.g., quantum theory, theory of relativity, age of the universe).

• Standard 5 Scientific Inquiry

• Organizer   Doing Scientific Inquiry

• Indicator 5.A.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

• Indicator 5.A.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.

• Indicator 5.A.5 Use appropriate summary statistics to analyze and describe data.

• Standard 6 Scientific Way of Knowing

• Organizer   Nature of Science

• Indicator 6.A.1 Give examples that show how science is a social endeavor in which scientists share their knowledge with the expectation that it will be challenged continuously by the scientific community and others.

• Organizer   Science and Society

• Indicator 6.C.11 Research how advances in scientific knowledge have impacted society on a local, national or global level.

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 3.E Summarize the historical development of scientific theories and ideas within the study of physical sciences.

• Benchmark 5.A Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

• Benchmark 6.A Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories.

• Benchmark 6.C Explain how societal issues and considerations affect the progress of science and technology.

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Energy

What is energy?
What are the different forms of energy?
When do objects have energy?
When/how is energy conserved?

The learner will calculate the work done by a specified constant force on a body that undergoes a specified displacement.
The learner will relate the work done by a force to the area under a graph of force as a function of the position, and calculate this work in the case where the force is a linear function of position.
The learner will calculate the change in kinetic energy or speed that results from performing a specified amount of work on a body.
The learner will calculate the work performed by the net force, or by each of the forces that makes up the net force, on a body that undergoes a specified change in speed or kinetic energy.
The learner will apply the work energy theorem to determine the change in a body's kinetic energy and speed that results from the application of specified forces.
The learner will apply the work energy theorem to determine the force that is required in order to bring a body to rest in a specified distance.
The learner will write an expression for the force exerted by an ideal spring and for the potential energy stored in a stretched or compressed spring.
The learner will calculate the potential energy of a single body in a uniform gravitational field.
The learner will identify situations in which mechanical energy is or is not conserved.
The learner will apply conservation of energy in analyzing the motion of bodies that are moving in a gravitational field and are subject to constraints imposed by strings or surfaces.
The learner will calculate the power required to maintain the motion of a body with constant acceleration.
The learner will calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer   Forces and Motion

• Indicator 3.D.5 Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.

• Standard 5 Scientific Inquiry

• Organizer   Doing Scientific Inquiry

• Indicator 5.A.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.

• Indicator 5.A.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

• Indicator 5.A.3 Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles, ventilation).

• Indicator 5.A.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.

• Indicator 5.A.5 Use appropriate summary statistics to analyze and describe data.

• Standard 6 Scientific Way of Knowing

• Organizer   Nature of Science

• Indicator 6.A.5 Describe how individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies, hundreds of people may work together on major scientific questions or technical problem).

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 5.A Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

• Benchmark 6.A Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Momentum and Simple Harmonic Motion

What is momentum?
How is momentum measured?
What does it mean to say that momentum is conserved?
The learner will relate mass, velocity, and linear momentum for a moving body, and calculate the total linear momentum of a system of bodies.
The learner will relate impulse to the change in linear momentum and the average force acting on a body.
The learner will identify situations in which linear momentum, or a component of the linear momentum vector, is conserved.
The learner will apply linear momentum conservation to determine the final velocity when two bodies that are moving along the same line, or at right angles, collide and stick together, and calculate how much kinetic energy is lost in such a situation.
The learner will determine the force that one spherically symmetrical mass exerts on another.
The learner will determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass.
The learner will recognize that the motion of objects in circular orbit does not depend on the body's mass.
The learner will describe quantitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit.
The learner will derive expressions for the velocity and period of revolution in a circular orbit.
The learner will apply conservation of angular momentum to determine the velocity and radial distance at any point in the orbit.
The learner will apply angular momentum conservation and energy conservation to relate the speeds of a body at the two extremes of an elliptic orbit.
The learner will sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude, period, and frequency of the motion for an object undergoing simple harmonic motion (SHM).
The learner will identify points in SHM where the velocity is zero or achieves its maximum positive or negative value.
The learner will state qualitatively the relation between acceleration and displacement is SHM.
The learner will identify points in SHM where the acceleration is zero or achieves its greatest positive or negative value.
The learner will state and apply the relation between frequency and period for simple harmonic motion.
The learner will state how the total energy of an oscillating system depends on the amplitude of the motion.

The learner will sketch or identify a graph of kinetic or potential energy as a function of time for SHM.
The learner will identify points in SHM where the energy is all potential or all kinetic.
The learner will apply the expression for the period of oscillation of a mass on a spring.
The learner will apply the expression for the period of a simple pendulum.
The learner will state what approximation must be made in deriving the period.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer Forces and Motion

• Indicator 3.D.5 Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.

• Standard 5 Scientific Inquiry

• Organizer Doing Scientific Inquiry

• Indicator 5.A.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.

• Indicator 5.A.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

• Indicator 5.A.3 Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles, ventilation).

• Indicator 5.A.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.

• Indicator 5.A.5 Use appropriate summary statistics to analyze and describe data.

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 5.A Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Electrostatics and Electric Circuits

What phenomena can be explained using electric charge?
How do electric circuits function?
What are the advantages and disadvantages of different types of circuits?
How do households use electricity?

The learner will define an electric field in terms of the force on a test charge.
The learner will calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field.
The learner will determine the direction of the field at a given point, given a diagram on which an electric field is represented by flux lines.
The learner will identify locations where the field is strong and where it is weak, given a diagram.
The learner will identify where positive or negative charges must be present given a diagram.
The learner will analyze the motion of a particle of specified charge and mass in a uniform electric field.
The learner will calculate the electrical work done on a positive or negative charge that moves through a specified potential difference.
The learner will determine the direction and approximate magnitude of the electric field at various positions, given a sketch of equipotentials for a charge configuration.
The learner will apply conservation of energy to determine the speed of a charged particle that has been accelerated through a specified potential difference.
The learner will calculate the potential difference between two points in a uniform electric field, and state which is at the higher potential.
The learner will determine the force that acts between specified point charges, and describe the electric field of a single point charge.
The learner will use vector addition to determine the electric field produced by two or more point charges.
The learner will relate the magnitude and direction of the current in a wire to the rate of flow of positive and negative charge.
The learner will relate current and voltage for a resistor.
The learner will describe how the resistance of a resistor depends upon its length and cross-sectional area.
The learner will apply the relations for the rate of heat production in a resistor.
The learner will identify on a circuit diagram resistors that are in series or in parallel.
The learner will determine the ratio of the voltages across resistors connected in series or the ratio of the currents through resistors connected in parallel.
The learner will calculate the equivalent resistance of two or more resistors connected in series or in

parallel, or of a network of resistors that can be broken down into series and parallel combinations.
The learner will calculate the voltage, current, and power dissipation for any resistor in such a network of resistors connected to a single battery.
The learner will design a simple series-parallel circuit that produces a given current and terminal voltage for one specified component, and draw a diagram for the circuit using conventional symbols.
The learner will calculate the terminal voltage of a battery of specified emf and internal resistance from which a known current is flowing.
The learner will apply Ohm's Law and Kirchhoff's rules to determine a single unknown current, voltage, or resistance.
The learner will state whether the resistance of a voltmeter and ammeter is high or low.
The learner will identify or show correct methods of connection meters into circuits in order to measure voltage or current.
The learner will describe how stored charge is divided between two capacitors connected in parallel.
The learner will determine the ratio of voltages for two capacitors connected in series.
The learner will calculate the voltage or stored charge for a capacitor connected to a circuit consisting of a battery and resistors.
The learner will determine voltages and currents immediately after a switch has been closed and also after steady-state conditions have been established.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer   Forces and Motion

• Indicator 3.D.7 Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear reactions (e.g., from atomic and hydrogen bombs and in the Sun and other stars).

• Standard 5 Scientific Inquiry

• Organizer   Doing Scientific Inquiry

• Indicator 5.A.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.

• Indicator 5.A.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 5.A Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Thermodynamics

How do ideal gases behave?
What are the principles of engines?
The learner will identify or sketch on a pVdiagram the curves that represent each of the above processes.
The learner will relate the heat absorbed by a gas, the work performed by the gas, and the internal energy change of the gas for any of the processes above.
The learner will relate the work performed by a gas in a cyclic process to the area enclosed by a curve on a pV diagram.
The learner will determine whether entropy will increase, decrease, or remain the same during a particular situation.
The learner will compute the maximum possible efficiency of a heat engine operating between two given temperatures.
The learner will relate the heats exchanged at each thermal reservoir in a Carnot cycle to the temperatures of the reservoirs.
The learner will state the connection between temperature and mean translational kinetic energy, and apply it to determine mean speed of gas molecules as a function of their mass and the temperature of the gas.
The learner will state the relation among Avogadro's number, Boltzmann's constant, and the gas constant R and express the energy of a mole of a monatomic ideal gas as a function of its temperature.
The learner will explain qualitatively how the model explains the pressure of a gas in terms of collisions with the container walls, and explain how the model predicts that, for fixed volume, pressure must be proportional to temperature.
The learner will relate the pressure and volume of a gas during an isothermal expansion or compression.
The learner will relate the pressure and temperature of a gas during constant volume heating or cooling, or the volume and temperature during constant pressure heating or cooling.
The learner will calculate the work performed on or by a gas during an expansion or compression at constant pressure.
The learner will understand the process of adiabatic expansion or compression of a gas.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer   Nature of Matter

• Indicator 3.A.2 Describe how a physical, chemical or ecological system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. Large disturbances may cause it to escape that equilibrium and eventually settle into some other state of equilibrium.

• Indicator 3.D.3 Explain how all matter tends toward more disorganized states and describe real world examples (e.g., erosion of rocks, expansion of the universe).

• Benchmark 3.A Explain how variations in the arrangement and motion of atoms and molecules form the basis of a variety of biological, chemical and physical phenomena.

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Organizer   Nature of Matter

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Content

What are waves?
What are their characteristics?
What phenomena can be explained using wave theory?

The learner will sketch or identify graphs that represent traveling waves and determine the amplitude, wavelength, and frequency of a wave from such a graph.
The learner will state and apply the relation among wavelength, frequency, and velocity for a wave.
The learner will sketch or identify graphs that describe reflection of a wave from the fixed or free end of a string.
The learner will write and apply the formula for the speed of waves on a string and know qualitatively what factors determine the speed of sound.
The learner will sketch possible standing wave modes for a stretched string that is fixed at both ends, and determine the amplitude, wavelength, and frequency of such standing waves.
The learner will describe possible standing sound waves in a pipe that has either open or closed ends, and determine the wavelength and frequency of such standing waves.
The learner will explain the mechanism that gives rise to a frequency shift in both the moving source and moving observer. Doppler effects and derive an expression for the frequency heard by the observer.
The learner will write and apply the equations that describe the moving source and moving observer Doppler effect, and sketch or identify graphs that describe the effect.
The learner will apply the principle of superposition to describe how a standing wave may be formed.
The learner will describe the conditions under which the waves reaching an observation point from two or more sources will all interfere constructively or destructively.
The learner will determine locations of interference maxima or minima for two sources or determine the frequencies or wavelengths that can lead to constructive or destructive interference at a certain point.
The learner will relate the amplitude and intensity produced by two or more sources that interfere constructively to the amplitude and intensity produced by a single source.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer Forces and Motion

• Indicator 3.D.8 Describe how the observed wavelength of a wave depends upon the relative motion of the source and the observer (Doppler Effect). If either is moving towards the other, the observed wavelength is shorter; if either is moving away, the observed wavelength is longer (e.g., weather radar, bat echoes, police radar).

• Standard 4 Science and Technology

• Organizer   Understanding Technology

• Indicator 4.A.1 Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.

• Indicator 4.A.4 Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.

• Standard 5 Scientific Inquiry

• Organizer   Doing Scientific Inquiry

• Indicator 5.A.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

• Indicator 5.A.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.

• Indicator 5.A.5 Use appropriate summary statistics to analyze and describe data.

• Standard 6 Scientific Way of Knowing

• Organizer   Nature of Science

• Indicator 6.A.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator/prey relationships, properties of semiconductors).

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 4.A Predict how human choices today will determine the quality and quantity of life on Earth.

• Benchmark 5.A Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

• Benchmark 6.A Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories.

AP Physics

GRADE TWELVE

Core Ideas/Cross Cutting Concepts

Modern Physics

How does light behave as both a particle and a wave?
What parts of the quantum theory differ from classical physics?
How are energy and mass related in nuclear decay?

The learner will describe the Rutherford scattering experiment and explain how it provides evidence for the existence of the atomic nucleus.
The learner will relate the energy of a photon in joules or electro-volts to its wavelength or to its frequency.
The learner will relate the linear momentum of a photon to its energy or wavelength, and apply linear momentum conservation to simple processes involving the emission, absorption, or reflection of photons.
The learner will calculate the number of photons per second emitted by a monochromatic source of specific wavelength and power.
The learner will describe a typical photoelectric effect experiment, and explain what experimental observations provide evidence for the photon nature of light.
The learner will describe qualitatively how the number of photoelectrons and their maximum kinetic energy depend on the wavelength and intensity of the light striking the surface, and account for this dependence in terms of a photon model of light.
The learner will determine the maximum kinetic energy of photoelectrons for a different photon energy or wavelength when given the maximum kinetic energy of photoelectrons ejected by photons of one energy or wavelength.
The learner will sketch or identify a graph of stopping potential versus frequency for a photoelectric effect experiment, determine from such a graph the threshold frequency and work function, and calculate an approximate value of h/e.
The learner will calculate the energy or wavelength of the photon emitted or absorbed in a transition between specified levels, or the energy or wavelength required to ionize an atom.
The learner will explain qualitatively the origin of emission or absorption spectra of gases.
The learner will calculate the wavelength or energy for a single step transition between the same levels, given the wavelengths or energies of photons emitted or absorbed.
The learner will write an expression for the energy levels of hydrogen in terms of the ground state energy, draw a diagram to depict these levels, and explain how this diagram accounts for the various series in the hydrogen spectrum.
The learner will state the assumptions and conclusions of the Bohr model for the hydrogen atom.

The learner will calculate the De Broglie wavelength of a particle as a function of its momentum.
The learner will describe the Davisson-Germer experiment, and explain how it provides evidence for the wave nature of electrons.
The learner will calculate the shortest wavelength of x-rays that may be produced by electrons accelerated through a specified voltage.
The learner will describe Compton's experiment, and state what results were observed and by what sort of analysis these results may be explained.
The learner will account qualitatively for the increase of photon wavelength that is observed, and explain the significance of the Compton wavelength.
The learner will recognize that half-life is independent of the number of nuclei present or of external conditions.
The learner will sketch or identify a graph to indicate what fraction of a radioactive sample remains as a function of time, and indicate the half-life on such a graph.
The learner will determine, for an isotope of specified half-life, what fraction of the nuclei have decayed after a given time has elapsed.
The learner will use conservation of mass number and charge to complete nuclear reactions.
The learner will determine the mass number and charge of a nucleus after it has undergone specified decay processes.
The learner will describe the process of alpha, beta, and gamma decay and write a reaction to describe each.
The learner will explain why the neutrino's existence had to be postulated in order to reconcile experimental data with fundamental conservation laws.
The learner will compare the strength and range of the nuclear force to that of the electromagnetic force.
The learner will describe a typical neutron induced fission, and explain why a chain reaction is possible.
The learner will relate the energy released in fission to the decrease in rest mass.

Learning Targets:

• Standard 3 Physical Sciences

• Organizer   Forces and Motion

• Indicator 3.D.7 Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear reactions (e.g., from atomic and hydrogen bombs and in the Sun and other stars).

• Organizer   Nature of Energy

• Indicator 3.B.10 Explain the characteristics of isotopes. The nucleus of radioactive isotopes is unstable and spontaneously decays emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate.

• Indicator 3.B.11 Use the predictability of decay rates and the concept of half-life to explain how radioactive substances can be used in estimating the age of materials.

• Indicator 3.C.12 Describe how different atomic energy levels are associated with the electron configurations of atoms and electron configurations (and/or conformations) of molecules.

• Indicator 3.C.13 Explain how atoms and molecules can gain or lose energy in particular discrete amounts (quanta or packets); therefore they can only absorb or emit light at the wavelengths corresponding to these amounts.

• Organizer   Historical Perspectives and Scientific Revolutions

• Indicator 3.E.14 Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., nuclear energy, quantum theory, theory of relativity).

• Indicator 3.E.15 Describe concepts/ideas in physical sciences that have important, long-lasting effects on science and society (e.g., quantum theory, theory of relativity, age of the universe).

• Indicator 6.A.1 Give examples that show how science is a social endeavor in which scientists share their knowledge with the expectation that it will be challenged continuously by the scientific community and others.

• Indicator 6.A.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator/prey relationships, properties of semiconductors).

• Indicator 6.A.5 Describe how individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies, hundreds of people may work together on major scientific questions or technical problem).

• Organizer   Science and Society

• Indicator 6.C.9 Recognize the appropriateness and value of basic questions “What can happen?” “What are the odds?” and “How do scientists and engineers know what will happen?”

• Benchmark 3.B Recognize that some atomic nuclei are unstable and will spontaneously break down.

• Benchmark 3.C Describe how atoms and molecules can gain or lose energy only in discrete amounts.

• Benchmark 3.D Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

• Benchmark 3.E Summarize the historical development of scientific theories and ideas within the study of physical sciences.

• Benchmark 6.C Explain how societal issues and considerations affect the progress of science and technology.

• Organizer   Nature of Energy