HIGH SCHOOL ELECTIVE
PHYSICS (USED AS A YEAR-LONG OR BLOCK-SCHEDULED COURSE)
Physical Sciences Standard (PS)

11-12 Benchmarks	Grade Level Indicators and Sub-Objectives	Teaching Strategies/Resources
By the end of the 11-12 program, the student will, **Physical Sciences** **✶ Recognize that some atomic nuclei are unstable and will spontaneously break down. (PS-B)** **✶ Describe how atoms and molecules can gain or lose energy only in discrete amounts. (PS-C)** **✶ Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems. (PS-D)** **✶ Summarize the historical development of scientific theories and ideas within the study of physical sciences. (PS-E)**	**By the end of Eleventh/Twelfth Grades, the student will:** **Nature of Matter** **✶ Explain how all matter tends toward more disorganized states and describe real world examples (e.g., erosion of rocks and expansion of the universe). (PS-12-3)** **✶ Recognize that at low temperatures some materials become superconducting and offer little or no resistance to the flow of electrons. (PS-12-4)** **Forces and Motion** **✶ Describe real world examples showing that all energy transformations tend toward disorganized states (e.g., fossil fuel combustion, food pyramids and electrical use). (PS-11-3)** **✶ Explain how electric motors and generators work (e.g., relate that electricity and magnetism are two aspects of a single electromagnetic force). Investigate that electric charges in motion produce magnetic fields and a changing magnetic field creates and electric field). (PS-11-4)** **✶ Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically. (PS-12-5)** **✶ Recognize that the nuclear forces that hold the nucleus of an atom together, at nuclear distances, are stronger than the electric forces that would make it fly apart. (PS-12-6)** **✶ 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). (PS-12-7) **✶ 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 and police radar). (PS-12-8)** **✶ Describe how gravitational forces act between all masses and always create a force of attraction. Recognize that the strength of the force if proportional to the masses and weakens rapidly with increasing distance between them. (PS-12-9)** **<u>Nature of Energy</u>** **✶ 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. (PS-12-13)** **<u>Historical Perspectives and Scientific Revolutions</u>** **✶ 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 and theory of relativity). (PS-12-14)** **✶ 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). (PS-12-15)** **<u>Sub-Objectives to Meet Indicators:</u>** **Mechanics** • Describe basic units of the metric system. • Convert simple units into each other. • Differentiate among scalar, vector, speed, velocity, displacement, and distance.	

	• Plot experimental data on position versus time graphs and use the data to produce speed versus time graphs. • Solve simple speed problems with equations and then graph the problems. • Solve simple vector problems involving adding velocity vectors. • Distinguish between speed and acceleration. • Describe acceleration of an object from speed versus time graphs and position versus time graphs. • Apply centripetal acceleration formulas to solve circular motion problems. • Solve problems with simple equations for accelerated motion. • Given appropriate data, predict position and velocity for any projectile. • Convert into and out of scientific notation. • Find percentage of difference and percentage of error for experimentally derived data. • Describe mass, weight, and force. • Distinguish between balanced and unbalanced motion. • Apply Newton's First Law of Motion (inertia) to explain any motion. • Discover the relationship between mass and force for an accelerating object using experimental data. • Use significant figures in calculations correctly. • Use Newton's Second Law of Motion to define the SI force unit and solve problems. • Explain the Universal Law of gravitation. • Apply the Universal Law of Gravitation to explain weight and weightlessness. • Compare gravitational fields of various planets. • Distinguish between momentum and impulse. • Solve problems involving impulse and momentum. • Analyze motion for objects moving in curved paths. • Analyze motion of objects in terms of Newton's three laws. • Analyze actual situations of rocket launches versus a model rocket's situation to explain why prediction can be wrong. • Describe forces acting on an object that is in equilibrium. • Determine the resultant and equlibriant of concurrent forces and use them to identify missing forces. • Find components of vector forces and use to solve problems. • Analyze force situations and solve vector problems involving resultants	

	and component forces. • Investigate the Law of Torque and use it to describe rotation around any point. • Explain center of gravity and explain how to find the center of gravity. • Solve problems involving center of gravity and parallel forces. • Differentiate among work, power and energy. • Solve problems with work, power and energy. • Use efficiency to solve simple problems. • Describe equivalency of matter and energy. • Describe evidence for existence of molecules. • Explain what happens to an object as its velocity approaches the speed of light. • Apply energy considerations to analyze a trajectory or a roller coaster ride problem. • Discuss the particle nature of matter in terms of molecules. **Kinetic Molecular Theory** • Explain phenomena in terms of Kinetic Molecular Theory. • Discuss origin of forces within fluids and list their effects on fluids. • Solve simple fluid pressure problems. • Distinguish among states of matter, including colloids. • Differentiate between crystalline and amorphous solids. • Explain how properties of fluids are explained by the Kinetic Molecular Theory. • Describe intermolecular forces and their effects on solids. • Distinguish between adhesion and cohesion and describe how they affect matter. • Recognize the elastic behavior of everyday objects and explain this behavior in terms of intermolecular forces. • Explain Hooke's Law. • Predict volume changes brought on by pressure changes and vice versa. • Differentiate between heat and temperature. • Discuss the role of kinetic energy in the internal heat energy of matter. • Explain the operation of thermometers. • Compare and contrast Kelvin, Fahrenheit, and Celsius temperature scales. • Describe applications of thermal expansion and problems caused by it.	

	• Discuss some important results caused by the changes in volume when materials melt or freeze. • Distinguish between calories and Joules. • Discuss mechanic equivalent of heat and its relation to the laws of thermodynamics. • Use a calorimeter properly to predict heat transfer. • Using experimental data, generalize the First Law of Thermodynamics. • Explain why it takes so much energy to melt ice and outline some consequences of this. • Solve simple problems involving heat and fusion. • Explain why it takes so much energy to evaporate water and point out consequences. • Solve simple problems involving heat of vaporization. • Provide convincing evidence that there is absolute zero and you can discover it without cooling a gas to any appreciable extent. • Solve simple problems with Charles' Law, Boyle's Law, and the Ideal Gas Law. • Explain the four steps involved in common heat engines and describe ways in which an understanding of heat engines has influenced civilization. **Electricity and Magnetism** • Define the concept of charge and state the SI unit for charge. • Explain the basic properties of charge including attraction, repulsion, and conservation. • Distinguish between insulators and conductors. • Differentiate among charging by friction, conduction, and induction. • Explain the concept of electric field, including how to determine its direction. • Explain the concept of electric shielding, that the electric field inside a charged conductor is zero. • Compare and contrast volt, electric current, and electric resistance. • Explain Ohm's Law. • Solve simple problems using Ohm's law. • Calculate equivalent resistances for series and parallel combinations of resistors. • Interpret simple schematic diagrams and be able to distinguish between	

	parallel and series circuits. • Perform simple circuit analyses on series and parallel circuits. • Explain the Domain Theory of Magnetism. • Determine magnetic field strengths and directions. • Distinguish between an electromagnet and an earth magnet. • Explain what factors determine the strength of an electromagnet. • Determine the direction of a magnetic field around current-carrying conductors. • Calculate an induced EM using Faraday's Law. **Sound and Sound Waves** • Distinguish between harmonic and periodic motion. • Compare and contrast amplitude, frequency, and period. • Determine the period of a harmonic oscillating spring. • Determine the period of a pendulum. • Calculate displacement, velocity, and acceleration for harmonic motion. • Distinguish between longitudinal and transverse waves. • Explain the properties and characteristics of waves, including reflection, refraction, diffraction, and interference. • Solve problems incorporating wave speed, frequency, and wavelength. • Explain the relationship between intensity and intensity level (decibels). • Explain the relationship between frequency and pitch. • Solve problems involving intensity levels. • Explain the human hearing thresholds of audibility while incorporating the dependence upon frequency. • Distinguish harmonics from pictorial representations of waves. • Calculate fundamental frequencies and harmonics for both closed and open pipes. • Explain resonance and distinguish between resonance and sympathetic vibrations. • Solve problems involving the Doppler Effect. • Calculate beats and beat frequencies. **Light** • Distinguish among reflection, refraction, diffraction, and interference. • Determine when each of the above do or do not occur. • Define angle of incidence and normal.	

	• Calculate angles of reflection. • Distinguish among plane, concave, and convex mirrors. • Determine the focal length of a curved mirror. • Determine image characteristics using the mirror equation. • Draw ray diagrams for the different types of mirrors. • Explain spherical aberration and explain how to correct for it. • Explain the concept of index or refraction. • Calculate angles of refraction using Snell's Law. • Distinguish between converging and diverging lenses. • Determine the focal length of a thin lens. • Determine image characteristics using the Lens Equation. • Explain chromatic aberration and how to correct it. • Explain the significance of Thomas Young's Double Slit experiment. • Distinguish between polarized and non-polarized light. • Solve problems for single, double, and multiple-slit diffraction patterns. • Explain why thin-film interference occurs. • Solve problems for Brewster's angle. • Explain why the sky appears blue, clouds appear white, and sunsets/sunrises appear red.	