Physics I Curriculum Guide

Introduction:

In high school Introductory Physics (or physical science), students recognize the nature and scope of physics, including its relationship to the other sciences. Students learn about basic topics such as motion, forces, energy, heat, waves, electricity, and magnetism. They learn about natural phenomena by using physical laws to calculate quantities such as velocity, acceleration, momentum, and energy. Students of introductory physics (or physical science) learn about the relationships between motion and forces through Newton's laws of motion. They study the difference between vector and scalar quantities and learn how to solve basic problems involving these quantities. Students learn about conservation of energy and momentum and how these are applied to everyday situations. They learn about heat and how thermal energy is transferred throughout the different phases of matter. Students extend their knowledge of waves and how they carry energy. Students gain a better understanding of electric current, voltage, and resistance by learning about Ohm's law. They also gain knowledge about the electromagnetic spectrum in terms of wavelength and frequency.

To be successful in this course, students are expected to know the content of the MA Mathematics Curriculum Framework, through grade 8.

	Student Performance Objectives	Resources / Activities (Cornerstone Activities in Bold)
Mathematical Standards	**Skills from the Mathematics Framework.** The student will be able to: ☐ Construct and use tables and graphs to interpret data sets. ☐ Solve simple algebraic expressions. ☐ Perform basic statistical procedures to analyze the center and spread of data. ☐ Measure with accuracy and precision (e.g., length, volume, mass, temperature, time) ☐ Convert within a unit (e.g., centimeters to meters) ☐ Use common prefixes such as milli-, centi-, and kilo-. ☐ Use scientific notation, where appropriate. ☐ Use ratio and proportion to solve problems. **Skills not in the Mathematics Framework, but are necessary for a solid understanding in this course.** The student will be able to: ☐ Determine the correct number of significant figures. ☐ Determine percent error from experimental and accepted values. ☐ Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); time (s); force (N); speed (m/s); acceleration (m/s^2); frequency (Hz); work and energy (J); power (W); momentum (kg*m/s); electric current (A); electric potential difference/voltage (V); and electric resistance (**Ω**). ☐ Use the Celsius and Kelvin scales.	CPO PFC S&P WKSHT 1.2: Dimensional Analysis CPO PFC S&P WKSHT 1.3: Working with Quantities and Rates CPO PFC S&P WKSHT 1.3: Problem Solving with Rates CPO PFC S&P WKSHT 1.2: International System of Measurements CPO PFC M WKSHT: Scientific Notation CPO PFC M WKSHT: Ratios & Proportions in a Recipe

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Scientific literacy can be achieved as students inquire about the physical world. The physical science curriculum includes substantial hands-on laboratory experiences, as appropriate. Though the following skills will be weaved into the curriculum and practiced throughout the course, they will also be addressed at the beginning of the course as a stand-alone introductory unit.

Intro. Unit (~ 10 Classes)	Scientific Inquiry Skills Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Introductory Unit: Scientific Inquiry *Approximate Timeline: September* Skills	SIS1. Make observations, raise questions, and formulate hypotheses.	How do scientists know what questions to ask?	The student will know that: ☐ Science is based on facts, data, and evidence. ☐ Scientists observe the natural world and are curious about it. ☐ Scientists think critically about the natural world.	The student will be able to: ☐ Observe the world from a scientific perspective. ☐ Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge. ☐ Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.	**Measuring Main Street Activity** Psychic Physics Phish Activity Pendulum Lab
	SIS2. Design and conduct scientific investigations.	How do scientists collect data?	The student will know that: ☐ Scientists are creative. ☐ Scientists must possess excellent communication skills. ☐ Scientists relate complex ideas. ☐ Scientists use appropriate materials and follow safety guidelines when conducting an investigation.	The student will be able to: ☐ Articulate and explain the major concepts being investigated and the purpose of an investigation. ☐ Select required materials, equipment, and conditions for conducting an experiment. ☐ Identify independent and dependent variables. ☐ Write procedures that are clear and replicable. ☐ Employ appropriate methods for accurately and consistently making observations, making and recording measurements at appropriate levels of precision, and collecting data or evidence in an organized way. ☐ Properly use instruments, equipment, and materials including set-up, calibration, technique, maintenance, and storage. ☐ Follow safety guidelines.	Walk/Jog/Run Activity

Intro. Unit (~ 10 Classes)	Scientific Inquiry Skills Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Skills Introductory Unit: Scientific Inquiry *Approximate Timeline: September*	SIS3. Analyze and interpret results of scientific investigations.	How do scientists find patterns in nature?	The student will know that: ☐ Scientists must present their findings in a clear manner. ☐ Scientists may use mathematical relationships to find a pattern. ☐ Scientists may use graphs to find a pattern. ☐ Scientists analyze the reliability of their data. ☐ Scientists know that all data has error in it. ☐ Scientists form conclusions that either support or refute their hypothesis. ☐ Scientists think further about their investigation and plan for continued study.	The student will be able to: ☐ Present relationships between and among variables in appropriate forms. (Represent data and relationships between and among variables in charts and graphs. Use appropriate technology and other tools.) ☐ Use mathematical operations to analyze and interpret data results. ☐ Assess the reliability of data and identify reasons for inconsistent results, such as source of error or uncontrolled conditions. ☐ Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis. ☐ State questions raised by an experiment that may require further investigation.	CPO PFC S&P WKSHT 7.1: Indirect Measurement
	SIS4. Communicate and apply the results of scientific investigations.	How do scientists share their understanding of nature?	The student will know that: ☐ Scientists use an array of tools such as graphs, tables, and charts to explain their findings. ☐ Scientists use correct language (punctuation and spelling) to communicate their findings. ☐ Create models to simulate their findings.	The student will be able to: ☐ Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations. ☐ Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation. ☐ Explain diagrams and charts the represent relationships or variables. ☐ Construct a reasoned argument and respond appropriately to critical comments and questions. ☐ Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology and other tools to present findings. ☐ Use and refine scientific models that simulate physical processes or phenomena.	CPO PFC S&P WKSHT 1.2: Making Line Graphs

Learning Standards for a Full First-Year Course in High School Introductory Physics (or physical science.)

Unit 1 (~ 49 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Unit 1: Motion and Forces Approximate Timeline: Late September-December ***Central Concept:*** Newton's Laws of motion and gravitation describe and predict the motion of most objects.	1.1 Compare and contrast vector quantities (e.g., displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, work).	How can vectors be used to solve real-world problems	The student will know that: ☐ Scalars only have magnitude. ☐ Vectors have magnitude and direction. ☐ Vectors can be added or subtracted from component vectors to form a resultant vector. ☐ Arrows are used to represent vectors.	The student will be able to: ☐ Define and identify vector and scalar quantities. ☐ Provide examples of vector and scalar quantities. ☐ Apply an understanding of vectors to velocity, acceleration, force, and momentum. ☐ Graphically represent vector quantities. ☐ Add and subtract collinear vector quantities. ☐ Add vectors at right angles.	CPO PFC S&P WKSHT 6.1: Adding Displacement Vectors CPO PFC M WKSHT: 2-D Vectors CPO PFC M WKSHT: Pythagorean Theorem
	1.2 Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.	How can words be used to describe an object's motion?	The student will know that: ☐ Distance is a scalar that is measured in meters and tells you how far an object travels. ☐ Displacement is a vector that is measured in meters and is found by subtracting the end point from the start point and tells you where the object stopped compared to where it started. ☐ Average speed is a scalar that is measured in m/sec and is found by dividing the total distance. ☐ Average velocity is a vector that is measured in m/sec and is found by dividing the displacement by the total time. ☐ Acceleration is a vector that is measured in m/sec^2 and is found by dividing the change in velocity by the change in time. ☐ Instantaneous speed is the speed at a particular moment in time. ☐ Average speed is a weighted average of all the instantaneous speeds during a trip.	The student will be able to: ☐ Define and calculate the distance and displacement of an object. ☐ Define and calculate the average speed and average velocity of an object. ☐ Distinguish among average speed, average velocity, and acceleration. ☐ Distinguish between average speed and instantaneous speed. ☐ Solve mathematical problems involving distance, displacement, speed, velocity, and acceleration.	CPO PFC S&P WKSHT 1.3: Speed Problems CPO PFC S&P WKSHT 2.2: Acceleration Problems CPO PFC S&P WKSHT 2.2: Acceleration Due to Gravity CPO PFC S&P WKSHT 6.1: Projectile Motion Constant Motion Buggy Activity Accelerated Motion Labs ☐ Marble and Ramp Activity ☐ Ticker-tape Time Activity Combined Motion Lab ☐ Projectile Motion Activity

Unit 1 (~ 49 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Unit 1 (Cont'd): Motion and Forces *Approximate Timeline: Late September-December* ***Central Concept:*** Newton's Laws of motion and gravitation describe and predict the motion of most objects.	1.3 Create and interpret graphs of 1-dimensional motion, such as position vs. time, distance vs. time, speed vs. time, velocity vs. time, and acceleration vs. time where acceleration is constant.	How can a graph be used to describe an object's motion?	The student will know that: ☐ A position v. time graph can be used to represent the change in position of an object. ☐ The slope on a position v. time graph tells you the average speed of the object. ☐ A velocity v. time graph can be used to represent the change in velocity of an object. ☐ The slope on a velocity v. time graph tells you the average acceleration of the object.	The student will be able to: ☐ Create graphs of motion (position v. time, speed v. time, velocity v. time, and constant acceleration v. time.) ☐ Interpret graphs of motion (position v. time, speed v. time, velocity v. time, and constant acceleration v. time.) ☐ Read a "dot diagram" or "oil drop diagram" to identify an object's motion. ☐ Interpret a "dot diagram" or "oil dot diagram" to identify an object's motion.	CPO PFC S&P WKSHT 2.4: Analyzing Graphs of Motion Without Numbers CPO PFC S&P WKSHT 2.4: Analyzing Graphs of Motion With Numbers CPO PFC M WKSHT: Slope CPO PFC M WKSHT: Slope from a Graph Walk/Jog/Run Activity **Motion Detector Lab (PvT)** **Motion Detector Lab (VvT)** The Big Graph Rubber Band Car Project
	1.4 Interpret and apply Newton's three laws of motion.	What causes an object to change its state of motion?	The student will know that: ☐ Mass does not change no matter an object's location. ☐ Weight depends on both the mass and location of an object. ☐ Inertia is related to mass. ☐ The acceleration of an object depends on its mass and the net force acting on it. ☐ Every action force has an equal and opposite reaction force. ☐ Mass is measured in kilograms.	The student will be able to: ☐ Distinguish between mass and weight. ☐ Explain the relationship between mass and inertia. ☐ Solve problems that relate mass to weight. ☐ Explain inertia's role in the motion of objects. ☐ Solve problems relating acceleration, mass, and net force. ☐ Identify action / reaction pairs.	CPO PFC S&P WKSHT 2.1: Mass vs. Weight CPO PFC S&P WKSHT 2.2: Newton's Second Law Inertia Smorgasboard Activity Cart and Ramp Activity Balloon Rocket Project
	1.5 Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.	How are pictures used to show the forces acting on an object?	The student will know that: ☐ The following forces may be acting on an object (i.e., weight, normal, tension, applied, friction, air resistance.) ☐ Every force has a description that includes the direction the force acts and the situation in which it is present. ☐ Force is measured in Newtons (a.k.a., $Kg*m/sec^2$)	The student will be able to: ☐ Distinguish between contact and non-contact forces. ☐ Identify and describe the forces acting on an object. ☐ Draw a free-body diagram of the forces acting on an object. ☐ Interpret free-body diagrams. ☐ Find the net force from a free-body diagram.	CPO PFC S&P WKSHT 5.2: Equilibrium

Unit 1 (~ 49 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Unit 1 (Cont'd): Motion and Forces *Approximate Timeline: Late September-December* ***Central Concept***: Newton's Laws of motion and gravitation describe and predict the motion of most objects.	1.6 Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.	How does friction affect the motion of objects?	The student will know that: ☐ There are two forms of friction (i.e., static friction and kinetic friction.) ☐ Static friction holds objects in place. ☐ Kinetic friction slows objects down. ☐ The magnitude of the static friction force is greater than the magnitude of the kinetic friction force.	The student will be able to: ☐ Define static and kinetic friction. ☐ Identify if static or kinetic friction is present. ☐ Explain how static and kinetic friction impacts the motion of an object.	Demo: VDL and Force Sensor
	1.7 Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.	What factors affect the force of gravity acting on an object?	The student will know that: ☐ All objects exert a gravitation force on one another. ☐ The mass of each object is directly related to the force of gravity. ☐ The separation distance between object's has an inverse-square relationship with the force of gravity.	The student will be able to: ☐ Predict if and by how much the force of gravity changes based on the separation distance between the objects. ☐ Predict if and by how much the force of gravity changes based on the mass of the objects. ☐ Explain in words how the force of gravity is related to the mass and separation distances of the objects.	CPO PFC S&P WKSHT 6.3: Universal Gravitation CPO PFC S&P WKSHT: 18.1: Inverse Square Law
	1.8 Describe conceptually the forces involved in circular motion.	What causes an object to move in a circle?	The student will know that: ☐ Objects moving in a circle are accelerating because their direction is constantly changing. ☐ The net force acting on an object moving in a circle is called the centripetal force. ☐ The centripetal force is always directed inward to the center of the circle of motion. ☐ The centripetal force is a general force and can be due a friction, tension, gravity, or applied force.	The student will be able to: ☐ Define centripetal force. ☐ Identify if a centripetal force is present in a situation. ☐ Identify the type of centripetal force present. ☐ Explain what would happen to the motion of an object if the centripetal force disappears.	Demo: Constant Motion Buggy

Unit 2 (~ 17 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Unit 2: Conservation of Energy and Momentum *Approximate Timeline: January* ***Central Concept:*** The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.	2.1 Interpret and provide examples that illustrate the law of conservation of energy.	How is energy conserved in the universe?	The student will know that: ☐ Energy is a scalar quantity. ☐ Energy comes in many forms and is only apparent when it changes forms. ☐ Heat is a form of energy and results from friction. ☐ Energy is often lost to heat. ☐ Energy can never be created nor destroyed; it can only change forms. ☐ Energy is measured in joules (a.k.a., N∗m)	The student will be able to: ☐ Define the following terms: energy, potential energy, kinetic energy, gravitational potential energy, and elastic potential energy. ☐ Identify the types of energy present in a situation. ☐ Describe the following types of energy: mechanical, heat, chemical, nuclear, and electromagnetic. ☐ Draw energy path transfer diagrams.	WKSHT: Energy Transformations in common devices
	2.2 Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.	How is energy conserved when a ball is dropped?	The student will know that: ☐ The motion of an object can be described in terms of its energy. ☐ Gravitational potential energy is directly proportional to an object's position. ☐ Kinetic energy is directly proportional to the square the speed of an object. ☐ Gravitational potential energy decreases when an object falls. ☐ Kinetic energy increases when an object falls. ☐ The total energy at any point is equal to the sum of the KE and PE.	The student will be able to: ☐ Calculate gravitational potential energy. ☐ Calculate kinetic energy. ☐ Calculate the total energy. ☐ Use the law of conservation of energy to determine the PE, KE, and TE of an object in motion.	Demo: Pendulum CPO PFC S&P WKSHT 3.2: Potential and Kinetic Energy Simulation: PhET – Energy Skate Park

Unit 2 (~ 17 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
Unit 2 (Cont'd): Conservation of Energy and Momentum *Approximate Timeline: January* ***Central Concept:*** The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.	2.3 Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.	What happens to energy when work is done?	The student will know that: ☐ Work is done when an object moves in the direction it is pushed or pulled. ☐ The amount of work that is done on an object is proportional to the force applied and the distance it moves. ☐ Work equals force times distance. ☐ When work is done on an object, its energy changes. ☐ When an object's energy changes, work has been done on it. ☐ Work is measured in Joules (a.k.a., N∗m)	The student will be able to: ☐ Define work. ☐ Determine if work is done on an object in different situations. ☐ Calculate the amount of work done on an object. ☐ Determine the change of energy of an object.	CPO PFC S&P WKSHT 3.2: Work CPO PFC S&P WKSHT 4.1: Work Done Against Gravity
	2.4 Describe both qualitatively and quantitatively the concept of power as work done per unit time.	How much power is required to climb a set of stairs?	The student will know that: ☐ The power rating of a machine is directly proportional to the amount of work it does. ☐ The power rating of a machine is inversely proportional to the amount of time it takes to do the work. ☐ A machine that does the same amount of work in less time is more powerful. ☐ Power is measured in Watts (a.k.a., Joules/sec) ☐ 1 Watt equals 746 horsepower (hp)	The student will be able to: ☐ Define power. ☐ Calculate the power rating of mechanical objects. ☐ Convert between watts and horsepower.	CPO PFC S&P WKSHT 4.1: Power CPO PFC S&P WKSHT 10.2: Power in Flowing Energy **Human Work and Power Activity**

Unit 2 (~ 17 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
2. Conservation of Energy and Momentum *Approximate Timeline: January* ***Central Concept:*** The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.	2.5 Provide and interpret examples showing that linear momentum is the product of mass and velocity, and is always conserved (law of conservation of momentum). Calculate the momentum of an object.	How is momentum conserved in collisions?	The student will know that: ☐ The momentum of an object is directly proportional to its mass and velocity. ☐ Momentum equals mass times velocity. ☐ Momentum is a vector quantity. ☐ The total amount of momentum is a system is equal before a collision and after a collision. ☐ There are two types of collisions: elastic and inelastic. ☐ Elastic collisions occur when objects collide and bounce off each other. ☐ Inelastic collisions occur when objects collide and stick to each other. ☐ The forces acting on objects involved in a collision follow Newton's 3rd Law of Motion; they are action/reaction pairs. ☐ The unit for momentum is kg ∗ m/sec. ☐ Impulse equals force times time. ☐ Changes in momentum are due to impulses. ☐ Impulses cause changes in momentum. ☐ The unit for impulse is kg ∗ m/sec.	The student will be able to: ☐ Calculate an object's momentum. ☐ Identify a collision as being elastic or inelastic. ☐ Predict the velocity of an object after it experiences an elastic collision. ☐ Predict the velocity of an object after it experiences an inelastic collision. ☐ Explain how an object that explodes has no net momentum after the explosion. ☐ Explain how car airbags work. ☐ Calculate the impulse an object experiences. ☐ Explain the relationship between impulse and momentum. ☐ Explain how to create a "safe" collision. ☐ Explain how a lacrosse stick works. ☐ Explain how a karate chop works.	CPO PFC S&P WKSHT 3.1: Momentum CPO PFC S&P WKSHT 3.1: Impulse CPO PFC S&P WKSHT 3.1: Momentum Conservation CPO PFC S&P WKSHT 3.2: Collisions and Conservation of Momentum **Qualitative Collision Activity with Pasco Tracks and Carts** Quantitative Collision Activity **The Egg Drop Project**

Unit 3 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
3. Heat and Heat Transfer *Approximate Timeline: February* ***Central Concept:*** Heat is energy that is transferred by the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.	3.1 Explain how heat energy is transferred by convection, conduction, and radiation.	How does a thermos keep liquids hot (and cold)?	The student will know that: ☐ There are three methods of heat transfer. ☐ Conduction is heat transfer by touch. ☐ Convection is heat transfer by currents. ☐ Radiation is heat transfer by infrared light.	The student will be able to: ☐ Define the three methods of heat transfer. ☐ Explain how each heat transfer mechanism can be slowed down. ☐ Identify the primary method of heat transfer in a situation. ☐ Explain how a thermos works.	Demos: Metal Star, Convection Tube, Lamps
	3.2 Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.	How does insulation work?	The student will know that: ☐ Objects that are at different temperatures are in contact will reach thermal equilibrium. ☐ Heat always flows from hot objects to cold objects. ☐ An object feels cold to the touch because your body is losing heat energy when it touches it. ☐ Insulation slows the transfer of heat from one object to another.	The student will be able to: ☐ Predict the equilibrium temperature of objects that are in contact with one another. ☐ Determine the direction that heat is flowing.	CPO PFC S&P WKSHT 7.2: Temperature Scales CPO PFC M WKSHT: Functions – Conversions Between Celsius & Fahrenheit **Thermal Equilibrium Lab**

Unit 3 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
3. Heat and Heat Transfer *Approximate Timeline: February* ***Central Concept:*** Heat is energy that is transferred by the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.	3.3 Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling, and warming.	Why does your hand feel cold when you hold and ice cube?	The student will know that: ☐ Thermal energy is proportional to the average kinetic energy in a substance. ☐ The faster the molecules of a substance are moving, the hotter it is. ☐ Heat is thermal energy in transit. ☐ There are four phases of matter (i.e., solid, liquid, gas, plasma.) ☐ The four phases of matter can be described by their thermal energy. ☐ Heating an object can cause its temperature to rise. ☐ There are four common types of phase changes. ☐ The four common types of phase changes are melting, freezing, condensing, and evaporating. ☐ Boiling happens at the bottom of a liquid; evaporation happens at the surface. ☐ Heating an object can cause a phase change. ☐ When heat is added to an object and it changes phase, its temperature does not change. ☐ Heat is released when objects change phase from gas to liquid, or liquid to solid. ☐ Heat is absorbed when objects change phase from solid to liquid, or liquid to gas.	The student will be able to: ☐ Describe the relationship between average kinetic energy and thermal energy. ☐ Determine if an object's molecules are moving relatively fast or slow. ☐ Define heat and thermal energy. ☐ Identify the four phases of matter and rank them based on the average kinetic energy. ☐ Distinguish between sensible and latent heating. ☐ Identify and define the four types of phase changes. ☐ Differentiate between boiling and evaporating. ☐ Explain the reason why an object's temperature does not change when heat is added to it. ☐ Explain the reason why an object's temperature does not change when heat is removed from it. ☐ Identify the phase changes that release heat energy. ☐ b Identify the phase changes that absorb heat energy. ☐ Explain why citrus growers spray their crops with a light mist before a freeze.	**Boiling Ice Lab** Make Ice Cream

Unit 3 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
3. Heat and Heat Transfer *Approximate Timeline: February* ***Central Concept:*** Heat is energy that is transferred by the processes of conduction, convection, and radiation between objects or regions that are at different temperatures.	3.4 Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.	When you are at a beach in the summer, why does the sand feel so hot while the ocean water feels so cool?	The student will know that: ☐ The heat of an object is equal to its mass times its change in temperature times it specific heat capacity. ☐ The specific heat capacity of an object is a measure of how much heat energy is needed to raise the temperature of a 1gram object by 1°C. ☐ The specific heat capacity of water is 1.0 cal/g°C. ☐ Objects with relatively high specific heat capacities require a lot of heat energy to change their temperatures. ☐ Objects with relatively low specific heat capacities require little heat energy to change their temperatures. ☐ Water has a high specific heat capacity compared to sand. ☐ Specific heat capacity is a physical property of a material. ☐ Heat is measured in calories (cal) or joules (j). ☐ 1,000 cal (science) = 1 Calorie (food) ☐ 1 cal = 4.184 joules	The student will be able to: ☐ Calculate the amount of heat needed to raise the temperature of an object. ☐ Compare the thermal inertia of various objects. ☐ Identify an object by its specific heat capacity.	CPO PFC S&P WKSHT 7.3: Specific Heat **Mystery Metal Lab**

Unit 4 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
4. Waves *Approximate Timeline: March* ***Central Concept:*** Waves carry energy from place to place without transfer of matter.	4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.	How can we use our observations of ocean waves to understand sound and light waves?	The student will know that: ☐ Any motion that has a repetitive characteristic is called simple harmonic motion (i.e., pendulums, springs, and waves.) ☐ Waves are caused by a disturbance. ☐ Waves are defined as a wiggle in space and time. ☐ Waves transfer energy and carry information from source to receiver. ☐ All waves have measurable properties. ☐ A wave crest is the highest point on a wave. ☐ A wave trough is the lowest point on a wave and is measured in meters. ☐ The amplitude of a wave is the one-half the distance from a crest to a trough and is measured in meters. ☐ The wavelength of a wave is the distance from one place on a wave to the same place on another wave (e.g., crest-to-crest) and is measured in meters. ☐ The velocity (wavespeed) of a wave is the found by measuring the amount of time it takes for one wavelength to pass and is measured in m/sec. ☐ The period of a wave is the amount of time for one wave to occur and is measured in seconds. ☐ The frequency of a wave is defined as the number of waves that occurs in 1-sec and is measured in Hertz (Hz). ☐ Wavespeed equals wavelength times frequency. ☐ Period equals 1/frequency. ☐ Frequency equals 1/period	The student will be able to: ☐ Identify examples of simple harmonic motion. ☐ Provide examples of simple harmonic motion. ☐ Define a wave. ☐ Identify the cause of a wave. ☐ Identify the measurable properties of a wave. ☐ Measure the properties of a wave. ☐ Use the wavespeed formula to calculate wavespeed, wavelength, and frequency. ☐ Determine the frequency of wave by knowing its period. ☐ Determine the period of a wave by knowing its frequency.	CPO PFC S&P WKSHT 20.1: Waves CPO PFC S&P WKSHT 19.1: Period and Frequency

Unit 4 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
4. Waves *Approximate Timeline: March* ***Central Concept:*** Waves carry energy from place to place without the transfer of matter.	4.2 Distinguish between mechanical and electromagnetic waves.	Why do you see lightning before you hear thunder?	The student will know that: ☐ Mechanical waves are caused by vibrations of matter. ☐ A medium is any type of matter (i.e., solid, liquid, gas.) ☐ Electromagnetic waves are caused by vibrations of electrical and magnetic fields. ☐ Mechanical waves need a medium to travel through. ☐ Electromagnetic waves do not need a medium to travel through (i.e., they can travel through a vacuum.) ☐ All electromagnetic waves travel a 3.00 x 10^8 m/sec in a vacuum.	The student will be able to: ☐ Differentiate between mechanical and electromagnetic waves. ☐ Define a medium and a vacuum. ☐ Describe the causes of mechanical and electromagnetic waves. ☐ Identify waves as mechanical or electromagnetic.	Video: Fireworks
	4.3 Distinguish between the two types of mechanical waves, transverse and longitudinal.	What are the different ways that matter can vibrate?	The student will know that: ☐ There are two types of mechanical waves: transverse waves and longitudinal waves. ☐ Longitudinal waves are created by a back-and-forth applied force. ☐ The energy in a longitudinal wave moves parallel to the direction of the applied force. ☐ The energy in a transverse waves moves perpendicular to the direction of the applied force. ☐ Longitudinal waves are made up of compressions and rarefactions. ☐ Transverse waves are made up crests and troughs. ☐ One wavelength is equal to the distance of one compression to another compression on the next wave. ☐ A sound wave is an example of longitudinal wave. ☐ A water wave is an example of a transverse wave.	The student will be able to: ☐ Identify mechanical waves as transverse or mechanical waves. ☐ Draw a longitudinal wave and label the compressions and rarefactions. ☐ Draw a transverse wave and label the crests and troughs. ☐ Label and measure the wavelength on a longitudinal wave. ☐ Label and measure the wavelength on a transverse wave.	**Slinky Lab**

Unit 4 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
4. Waves *Approximate Timeline: March* ***Central Concept***: Waves carry energy from place to place without the transfer of matter.	4.4 Describe qualitatively the basic principles of reflection and refraction of waves.	If all waves exhibit the same behavior, how do we use this understanding to explain why sound and light waves bounce and bend?	The student will know that: ☐ All waves reflect when they hit a surface. ☐ The normal line is 90° to the surface. ☐ The angle of incident is the angle at which the wave strikes the barrier and is measured with respect to the normal line. ☐ The angle of reflection is the angle at which the wave bounces off the barrier and is measured with respect to the normal line. ☐ The angle of incidence equals the angle of reflection. ☐ All waves bend when they enter a medium with a different density. ☐ When a wave enters a less dense material, the angle of refraction is greater than the angle of incidence. ☐ When a wave enters a more dense material, the angle of refraction is less than the angle of incidence. ☐ The angle of refraction is the angle of wave with respect to the normal line in the new medium. ☐ Waves change speed when they enter a new medium with a different density. ☐ Electromagnetic waves only travel at the speed of light in a vacuum.	The student will be able to: ☐ Define reflection. ☐ Define refraction. ☐ Identify and define the angle of incidence. ☐ Identify and define the angle of reflection. ☐ Identify and define the angle of refraction. ☐ Explain what happens when a wave reflects off surface. ☐ Explain why the angle of refraction is not equal to the angle of incidence when a wave travels from a less dense to a more dense material. ☐ Explain why the angle of refraction is not equal to the angle of incidence when a wave travels from a more dense to a less dense material. ☐ Predict the angle of reflection based on the angle of incidence. ☐ Predict the angle of refraction based on the new medium's density. ☐ Describe what happens to the speed of a wave when it enters a less dense medium. ☐ Describe what happens to the speed of a wave when it enters a more dense medium.	CPO PFC S&P WKSHT 23.1: The Law of Reflection CPO PFC S&P WKSHT 23.1: Refraction Pinhole Viewer Lab Shadow Lab **Mirror Lab** **Refraction Activity**

Unit 4 (~ 13 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
4. Waves *Approximate Timeline: March* ***Central Concept:*** Waves carry energy from place to placeofmatter. without transfer	4.5 Recognize that mechanical waves generally move faster through a solid than through a liquid and faster through a liquid than through a gas.	When you speak into a cup that is attached to a string, your friend who is holding the cup up to his or her ear can hear you. Why?	The student will know that: ☐ Mechanical waves move at different speeds in the different phases of matter. ☐ Mechanical waves move fastest through solids and slowest through gases. ☐ The molecular structure of matter is the cause for the difference in speed. ☐ Solids have tightly bound molecules and transfer vibrations more easily than liquids and gases. ☐ Mechanical waves (e.g., sound) do not travel through a medium. ☐ When a person speaks, he or she vibrates air. ☐ Eardrums vibrate in response to the energy traveling in the form of sound waves. ☐ Sound will travel faster in a solid than in a gas.	The student will be able to: ☐ Explain why sound does not travel in a vacuum. ☐ Explain why mechanical waves travel faster in solids than in liquids and gases. ☐ Describe the molecular structure of solids, liquids, and gases and explain how this affects the speed of a mechanical wave. ☐ Explain how a guitar works.	Demo: Ringing bell in vacuum.
	4.6 Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler effect).	Why does the pitch of an ambulance's siren sound different when it is moving toward you then when it is moving away from you?	The student will know that: ☐ The frequency of a sound wave is related to its pitch. ☐ High frequency sound waves have a high pitch. ☐ Low frequency sound waves have a low pitch. ☐ When a sound source is moving toward a receiver, the sound waves bunch up and have a higher frequency resulting in a higher pitch. ☐ When a sound source is moving away from a receiver, the sound waves spread out and have a lower frequency resulting in a lower pitch.	The student will be able to: ☐ Determine the frequency of a wave by measuring its wavelength and the time for one wave to occur. ☐ Identify sound waves with a high frequency ☐ Identify sound waves with a low frequency.	Demo: Doppler Effect **Doppler Effect Lab**

Unit 5 (~ 25 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources: Worksheets / Activities / Simulations
5. Electromagnetism *Approximate Timeline: April* ***Central Concept***: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.	5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.	How can you get a balloon to stick to a wall (without taping it)?	The student will know that: ☐ Materials that conduct electricity are known as conductors. ☐ Materials that do not conduct electricity are known as insulators. ☐ Most metals are conductors of electricity. ☐ Most non-metals are non-conductors of electricity. ☐ Some metals are better conductors than others. ☐ Metals have loose electrons which allows charge to flow through them.	The student will be able to: ☐ Identify materials that act as conductors of electricity. ☐ Identify materials that act as insulators of electricity. ☐ Explain why metals conduct electricity. ☐	Electroscope Activity **Electrophorous Activity** Demo: Van Der Graaff Simulation: PhET – Balloons and Static Electricity
	5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law).	What do "Danger – High Voltage" signs mean?	The student will know that: ☐ Current is measured in Amps (A) and is defined as the amount of charge moving in 1 sec. ☐ Voltage is measured in Volts (v) and is defined as the amount of energy in 1 coulomb of charge. ☐ Resistance is measured in Ohms (**Ω**) and is defined as the slowing of charge. ☐ Ohm's Law relates current, voltage, and resistance. ☐ Ohm's Law is: V = I x R, where V = voltage, I = current, and R = resistance. ☐ Current is directly related to voltage. ☐ Current is inversely related to resistance.	The student will be able to: ☐ Define and distinguish among current, voltage, and resistance. ☐ Identify the correct units for current, voltage, and resistance. ☐ Use Ohm's Law to calculate voltage, current, and resistance. ☐ Predict the change in current based on changes in voltage and resistance.	**Build A Simple Circuit Activity** CPO PFC S&P WKSHT 13.3: Ohm's Law Simulation: PhET – Circuit Construction Kit (DC Only)

Unit 5 (~ 25 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
5. Electromagnetism Approximate Timeline: April ***Central Concept*:** Stationary and moving charged particles result in the phenomena known as electricity and magnetism.	5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.	How are the lights in a house wired?	The student will know that: ☐ A circuit is a loop of conducting material. ☐ A series circuit has only one path to conduct electricity. ☐ A parallel circuit has more than one path to conduct electricity. ☐ Most circuits are a combination of series and parallel circuits. ☐ Circuit diagrams (schematics) can be drawn using universally agreed upon symbols. ☐ In a series circuit, the total voltage is equal to the sum of the voltage across each resistor. ☐ In a series circuit, the total current is the same through each resistor. ☐ In a series circuit, the total resistance is equal to the sum of all the resistors. ☐ In a parallel circuit, the total voltage is the same across each resistor. ☐ In a parallel circuit, the total current is equal to the sum of the current through each resistor. ☐ In a parallel circuit, as more resistors are added, the total resistance decreases.	The student will be able to: ☐ Identify the key components (i.e., battery, wire, switch, resistor, etc.) of a circuit. ☐ Draw a schematic of simple series, parallel, and combination circuits. ☐ Interpret schematics for simple series, parallel, and combination circuits. ☐ Apply Ohm's law to simple series, parallel, and combination circuits. ☐ Apply the rules for series and parallel circuits to find voltage, current, and resistance.	**Multimeter Activity – Series Circuits** **Multimeter Activity – Parallel Circuits** CPO PFC S&P WKSHT 13.2: Using a Multimeter CPO PFC S&P WKSHT 14.1: Series Circuit CPO PFC S&P WKSHT 13.3: Parallel Circuit

Unit 5 (~ 25 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
5. Electromagnetism *Approximate Timeline: April* ***Central Concept***: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.	5.4 Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb's law).	Why do you sometimes get a shock when you touch something?	The student will know that: ☐ Like charges repel and opposite charges attract. ☐ Coulomb's Law relates the amount of charge on objects and the distance between them to the electrostatic force. ☐ The electrostatic force t is directly proportional the amount of charge on an object. ☐ The electrostatic force is proportional to the inverse square of the separation distance between charges.	The student will be able to: ☐ Identify situations that involve attractive electrostatic forces. ☐ Explain how the amount of charge on an object impacts the electrostatic force. ☐ Explain how the separation distance between charged objects impacts the electrostatic force. ☐ Predict how the electrostatic force will be affected by changing the amount of charge or the separation distance. ☐ Find the resultant electrostatic force among charged objects.	**Charged Tape Activity** CPO PFC S&P WKSHT 15.2: Coulomb's Law CPO PFC S&P WKSHT: 18.1: Inverse Square Law
	5.5 Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.	Why is the "third rail" so dangerous?	The student will know that: ☐ Electrical power is similar to mechanical power. ☐ Power is defined as the energy transferred in a given amount of time (1 second.) ☐ Power is measured in joules/second (a.k.a., Watts.) ☐ Electrical bills are based on the amount of power consumed in a given time period. ☐ Power is equal to current times voltage. ☐ Current flows in a circuit when a voltage difference is present.	The student will be able to: ☐ Describe the similarity between electrical and mechanical power. ☐ Calculate the power rating of appliances given their voltage and current. ☐ Calculate the cost of running an appliance for a certain amount of time. ☐ Explain how current flows in a circuit when a potential difference is present.	CPO PFC S&P WKSHT 14.3: Electrical Power

Unit 5 **(~ 25 Classes)**	**Content Standards**	**Essential Questions**	**Student Performance Objectives (Knowledge)**	**Student Performance Objectives (Skills)**	**Resources / Activities** **(Cornerstone Activities in Bold)**
5. Electromagnetism *Approximate Timeline: April* ***Central Concept***: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.	5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies.	How do power-locks in a car work?	The student will know that: ☐ All magnets have a north and south pole. ☐ There are no monopole magnets. ☐ Magnets are made up domains which regions of aligned atoms. ☐ Electric charges can either be positive or negative. ☐ All magnets are surrounded by a 3-D magnetic field. ☐ Magnetic field lines point from the north pole to the south pole. ☐ All electric charges are surrounded by a 3-D electric field. ☐ Electric field lines point from the positive charge to the negative charge. ☐ Magnetic fields are strongest at the poles of a magnet. ☐ Electric charges can be either negative or positive. ☐ Magnetic and electric fields decrease in strength with distance. ☐ When a magnet is moved in and out of a coil of wire, an electric field is induced in the wire and charge moves. ☐ When charge moves through a wire, a magnetic field is induced around the wire. ☐ Moving charges induce magnetism. ☐ Moving magnets induce electricity. ☐ Electromagnets are temporary magnets.	The student will be able to: ☐ Draw the magnetic field lines surrounding different configurations of bar magnets. ☐ Draw the electric field lines surrounding different configurations of electric charges. ☐ Identify the two common parts (i.e., magnet and coil of wire) found in speakers, microphones, motors, or electric generators. ☐ Describe the energy transfer in a speaker, microphone, motor, or electric generator. ☐ Predict the relative strength of an electromagnet based on the number of coils present. ☐ Predict the relative strength of an electromagnet based on the current passing through the wire. ☐ Explain how an electromagnet works. ☐ Explain how a transformer can either step up or step down voltage. ☐ Explain how a speaker and microphones work. ☐ Explain how motors and electric generators work. ☐ Identify and explain a real-life use of an electromagnet. ☐ Explain how a solenoid works and identify a real-life use.	CPO PFC S&P WKSHT 17.3: Transformers **Make an Electromagnet Activity** Make a Simple Motor Activity Make a Simple Speaker Activity

Unit 6 (~ 6 Classes)	Content Standards	Essential Questions	Student Performance Objectives (Knowledge)	Student Performance Objectives (Skills)	Resources / Activities (Cornerstone Activities in Bold)
6. Electromagnetic Radiation *Approximate Timeline: May* ***Central Concept***: Oscillating electric of magnetic fields can generate electromagnetic waves over a wide spectrum.	6.1 Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.	What is light?	The student will know that: ☐ Electromagnetic waves are all light. ☐ Electromagnetic waves travel in a vacuum. ☐ Electromagnetic waves travel at the speed of light (3.00×10^8 m/sec). ☐ Electromagnetic waves are transverse waves. ☐ Electromagnetic waves are made up of an electrical component and a magnetic component. ☐ The components of an electromagnetic wave travel at right angles to each other.	The student will be able to: ☐ Explain the wave nature of light. ☐ Describe how electromagnetic radiation travels from the Sun to the Earth. ☐ Describe an electromagnetic wave in terms of its type and make-up.	CPO PFC S&P WKSHT 24.1: The Electromagnetic Spectrum
	6.2 Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.	How are electromagnetic waves used and what type of information do they carry?	The student will know that: ☐ The electromagnetic spectrum is made up of different forms of six different forms of light. ☐ The six different forms of light are radio waves, microwaves, infrared waves, visible light, ultraviolet rays, x-rays, and gamma rays. ☐ Electromagnetic waves all travel at the same speed but are distinguishable by their frequency. ☐ High-energy electromagnetic waves (gamma rays) have a higher frequency than low-energy electromagnetic waves (radio waves.) ☐ Electromagnetic waves with high frequencies have short wavelengths. ☐ Electromagnetic waves with low frequencies have long wavelengths.	The student will be able to: ☐ Identify the six regions of the electromagnetic spectrum. ☐ Explain a useful application of each of the regions of the electromagnetic spectrum. ☐ Classify the regions of the electromagnetic spectrum by energy, wavelength, and frequency.	CPO PFC S&P WKSHT 24.1: The Electromagnetic Spectrum

MCAS Prep *Approximate Timeline: May* (~ 5 Classes)	Each year, the Introductory Physics MCAS is administered for two days during the first week of June. For the 2010-2011 school year, the test will be administered on Wed, June 1 and Thu, June 2, 2011.	MCAS Review Packet: 1. Motion and Forces MCAS Review Packet: 2. Conservation of Energy and Momentum MCAS Review Packet: 3. Heat and Heat Transfer MCAS Review Packet: 4. Waves MCAS Review Packet: 5. Electromagnetism MCAS Review Packet: 6. Electromagnetic Radiation
End of Year Science, Technology, and Engineering Project *Approximate Timeline: June* (~ 5 Classes)	**Soda Bottle Rocket Project** Science seeks to understand the natural world, and often needs new tools to help discover the answers. Technologies (products and processes) are the result of engineered design which are created by technicians to solve societal needs and wants. Engineers use scientific discoveries to design products and processes that meet society's needs.	