Physics I
Standard 1: Constant Velocity in One and Two Dimensions
1.1: Develop graphical, mathematical and pictorial representations (such as a motion map) that describe the relationship among the clock reading and position of an object moving at a constant rate and apply those representations to qualitatively and quantitatively describe the motion of an object in one and two dimensions.
1.2: Describe the slope of the graphical representation of positon vs. clock reading in terms of the velocity of the object.
1.3: Rank the velocities of objects in a system based on the slope of a position vs. clock reading graphical representation. Recognize that the magnitude of the slope representing a negative velocity can be greater than the magnitude of the slope representing a positive velocity.
1.4: Describe the differences among the terms “distance”, “displacement”, “speed”, “velocity”, “average speed” and “average velocity” and be able to calculate any of those values given an object moving at a single constant velocity or with different constant velocities at different clock readings.
Standard 2: Constant Acceleration in One and Two Dimensions
2.1: Develop graphical, mathematical and pictorial representations (such as a motion map) that describe the relationship among the clock reading and velocity of an object moving at a changing rate and apply those representations to qualitatively and quantitatively describe the motion of an object in one and two dimensions.
2.2: Describe the slope of the graphical representation of velocity vs. clock reading in terms of the acceleration of the object.
2.3: Rank the accelerations of objects in a system based on the slope of a velocity vs. clock reading graphical representation. Recognize that the magnitude of the slope representing a negative acceleration can be greater than the magnitude of the slope representing a positive acceleration.
2.4: Given a graphical representation of the position, velocity or acceleration vs. clock reading, be able to identify or sketch the shape of the other two graphs.
2.5: Qualitatively and quantitatively apply the models of constant velocity and constant acceleration to determine the position or velocity of an object in moving in one or two dimensions in free fall near the surface of the Earth.
Standards 3: Forces in One Dimension
3.1: Construct and defend explanations of physical situations of an object which maintains its

current state of motion in the absence of a net external force according to Newton’s first law.
3.2: Develop graphical, mathematical and pictorial representations (such as a force diagram) that describe the relationship among the inertial mass of an object, the total force applied and the acceleration of an object in one dimension where one or more forces is applied to the object and apply those representations to qualitatively and quantitatively describe how an external force changes the motion of an object in one dimension.
3.3: Construct force diagrams using appropriately labeled vectors with magnitude, direction, and units to qualitatively and quantitatively analyze a scenario and make claims (develop arguments, justify assertions) about forces exerted on an object by other objects for different types of forces or components of forces.
3.4: Construct and defend explanations of physical situations involving the interaction of two objects using Newton’s third law and the representation of action-reaction pairs of forces.
3.5: Develop graphical and mathematical representations that describe the relationship among the gravitational mass of an object and the force due to gravity and apply those representations to qualitatively and quantitatively describe how changing the gravitational mass will affect the force due to gravity acting on the object and vice versa.
3.6: Describe the slope of the force due to gravity vs. mass graphical representation in terms of gravitational acceleration.
3.7: Explain that the equivalence of the inertial and gravitational masses leads to the observation that acceleration in free fall is independent of an object’s mass.
Standard 4: Energy in One Dimension
4.1: Evaluate the translational kinetic, gravitational potential and elastic potential energies in simple situations using the mathematical definitions of these quantities and mathematically relate the initial and final values of the translational kinetic, gravitational potential and elastic potential energies.
4.2: Identify the forms of energy present in a scenario and recognize that the potential energy is not stored in the object itself.
4.3: Describe “work” is the process of transferring of energy within a system when an object is moved under the application of an external force.
4.4: Operationally define “work” as the area under a force vs. change in position curve and be able to determine the amount of work done on a system by an unbalanced force over a change in position in one dimension.
4.5: Understand and apply the principle of conservation of energy to determine the total mechanical energy stored in a system and mathematically show that the total mechanical energy of the system remains constant as long as no dissipative (non-conservative) forces are

present.
4.6: Develop and apply pictorial, mathematical or graphical representations to qualitatively and quantitatively predict changes in the mechanical energy (translational kinetic, gravitational or elastic potential) of a system due to changes in position and speed of objects or frictional interactions within the system.
Standard 5: Linear Momentum In One Dimension
5.1: Define linear momentum as the product of an object's mass and its velocity and be able to quantitatively determine the linear momentum of a single object.
5.2: Apply Newton's second law to derive the impulse acting on an object as the product of the external force and the time over which the force is applied and as the change in an object's linear momentum.
5.3: Operationally define "impulse" as the area under a force vs. change in clock reading curve and be able to determine the change in linear momentum of a system acted on by an external force over a change in position in one dimension. Predict the change in linear momentum of an object from the average force exerted on the object and time interval during which the force is exerted.
5.4: Given a system with no external forces applied, apply Newton's Third Law to derive the conservation of linear momentum principle for a system consisting of two objects moving in one dimension and mathematically determine the initial or final momenta of an object in the system.
5.5: Calculate the total linear momentum of a two-body system. Apply the principle of conservation of momentum of a system moving in one dimension to mathematically show that the total linear momentum of the system remains constant when no external force is applied.
5.6: Mathematically determine the center of mass of a system consisting of two uniform masses. Given a system with no external forces applied, show that the linear momentum of the center of mass remains constant during any interaction between the masses.
5.7: Classify a given interaction between a system consisting of two objects as elastic or inelastic based on the change in linear kinetic energy of the system.
5.8: Demonstrate that when two objects interact through a collision or separation that the force experienced by and change in linear momentum of each object are equal and opposite, but as the mass of an object increases, the change in velocity of the object decreases.
Standard 6: Simple Harmonic Oscillating Systems
6.1: Develop graphical and mathematical representations that describe the relationship among the amount of stretch of a spring and the restoring force and apply those representations to qualitatively and quantitatively describe how changing the stretch or

compression will affect the restoring force and vice versa, specifically for a Hookean spring.
6.2: Describe the slope of the graphical representation of restoring force vs. change in length of an elastic material in terms of the elasticity of the material, specifically for a Hookean spring.
6.3: Develop graphical and mathematical representations which describe the relationship among the mass, stiffness and period of a simple horizontal mass-spring system and apply those representations to qualitatively and quantitatively describe how changing the mass or stiffness will affect the period of the system for a Hookean spring.
6.4: Develop graphical and mathematical representations which describe the relationship among the strength of gravity, length of string, and period of a simple mass-string (pendulum) system apply the those representations to qualitatively and quantitatively describe how changing the length of string or strength of gravity will affect the period of the system in the limit of small amplitudes.
6.5: Explain the limit in which the amplitude does not affect the period of a simple mass-spring or mass-string (pendulum) harmonic oscillating system.
Standard 7: Mechanical Waves and Sound
7.1: Differentiate between different oscillation modes such as transverse and longitudinal for a mechanical wave traveling in the horizontal direction.
7.2: Understand that a mechanical wave requires a medium to transfer energy, unlike an electromagnetic wave, and that only the energy is transferred by the mechanical wave, not the mass of the medium.
7.3: Develop graphical and mathematical representations that describe the relationship among the frequency of a mechanical wave and the wavelength of the wave and apply those representations to qualitatively and quantitatively describe how changing the frequency of a mechanical wave affects the wavelength and vice versa.
7.4: Describe the slope of the graphical representation of wavelength vs. the inverse of the frequency in terms of the speed of the mechanical wave.
7.5: Apply the mechanical wave model to sound waves and qualitatively and quantitatively determine how the relative motion of a source and observer affects the frequency of a wave as described by the Doppler Effect.
7.6: Qualitatively and quantitatively apply the principle of superposition to describe the interaction of two mechanical waves or pulses.
7.7: Qualitatively describe the phenomena of harmonic resonance and beat frequencies that arise from the addition of sound waves of slightly different frequency and define the beat frequency as the difference between the frequencies of two individual sound wave sources.

Standard 8: Simple Circuit Analysis
8.1: Develop graphical, mathematical and pictorial representations that describe the relationship among length, cross-sectional area and resistivity of an ohmic device and apply those representations to qualitatively and quantitatively describe how changing the physical properties of the device affect the resistance.
8.2: Describe the slope of the graphical representation of resistance vs. the ratio of length to cross-sectional area in terms of the resistivity of the material.
8.3: Develop graphical and mathematical representations that describe the relationship among the among the amount of current passing through an ohmic device and the amount of voltage (EMF) applied across the device according to Ohm's Law and apply those representations to qualitatively and quantitatively describe how changing the current affects the voltage and vice versa.
8.4: Describe the slope of the graphical representation of current vs. voltage or voltage vs. current in terms of the resistance of the device.
8.5: Qualitatively and quantitatively describe how changing the voltage or resistance of a simple series (loop) circuit affects the voltage, current and power measurements of individual resistive devices and for the entire circuit.
8.6: Qualitatively and quantitatively describe how changing the voltage or resistance of a simple parallel (ladder) circuit affects the voltage, current and power measurements of individual resistive devices and for the entire circuit.
8.7: Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum \Delta V = 0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches.
8.8: Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed.
8.9: Use a description or schematic diagram of an electrical circuit to calculate unknown values of current, voltage or resistance in various components or branches of the circuit. (Ohm's Law, Kirchhoff's Junction rule, Kirchhoff's Loop rule)