Physics Content Standards
St. Ignatius College Preparatory

Some materials adapted from California Content Standards.

Motion and Forces

1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:

    - Students know how to solve problems that involve constant speed and average speed.
    - Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
    - Students know how to apply the law F=ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).
    - Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
    - Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
    - Students know how to solve two-dimensional trajectory problems.
    - Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.
    - Students know how to solve two-dimensional problems involving balanced forces (statics).
    - Students know how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).
    - Students know force distributed of an area is pressure and that pressure x area to force.
    - Students know buoyancy is a result of the weight of the displaced fluid.
    - Students know objects will float at a level such that the mass of the displaced water is equal to the total mass of the displacing object

Conservation of Energy and Momentum

2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:

    - Students know how to calculate kinetic energy by using the formula $E_k=(1/2)mv^2$.
    - Students know how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) $E_g=mgh$ (h is the change in the elevation).

- Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.
- Students know how to calculate momentum as the product p=mv.
- Students know momentum is a separately conserved quantity different from energy.
- Students know an unbalanced force on an object produces a change in its momentum.
- Students know how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.
- Students know how to solve problems involving conservation of energy in simple systems with various sources of elastic energy, such as springs using the formula $E_k=(1/2)\ kx^2$.

Heat and Thermodynamics

3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:

    - Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.

Waves

4. Waves have the characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:

    - Students know waves carry energy from one place to another.
    - Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
    - Students know how to solve problems involving wavelength, frequency, and wave speed.
    - Students know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
    - Students know standing waves are due to the interaction of traveling waves of the same frequency and amplitude, moving in opposite directions.
    - Students know how to identify node and antinodes in a standing wave and the boundary conditions that cause these conditions.
    - Students can calculate the fundamental and harmonic frequencies of a standing wave.
    - Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves

whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).
- Students know how to identify the characteristic properties of waves: interference, superposition, and refraction.

Simple Harmonic Motion

5. Simple harmonic motion is the periodic, sinusoidal motion of an object. The motion is regular and repeating. As a basis for understanding this concept:

    - Students know the terms: period, frequency, amplitude, equilibrium point and restoring force.
    - Students know the restoring is proportional to and opposite in sign to the displacement from the equilibrium point. (Hooke's Law: $F= -kx$)
    - Students know two examples of SHM are pendulums and mass/spring systems.
    - Students know that the period of a pendulum is determined by $T = 2\pi\sqrt{(L/g)}$ and is not dependant on mass or amplitude.
    - Students know that the period of a mass/spring system is determined by $T = 2\pi\sqrt{(m/k)}$ and is not dependant on amplitude.
    - Students know that period and frequency are inversely related.
    - Students know resonance is the condition when the driving frequency matches the natural frequency of a system and can cite examples.

Electric and Magnetic Phenomena

6. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:

    - Students know how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
    - Students know how to solve problems involving Ohm's law.
    - Students know any resistive element in a DC circuit dissipates energy, which heats the resistor.
    - Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = IR (potential difference) x I (current) = I^2xR.
    - Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.
    - Students can calculate the force between two changed particle and know that similar charges produce repelling forces and opposite charges produce attractive forces.
    - Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

- Students know how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
- Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.
- Students know electric and magnetic fields contain energy and act as vector force fields.
- Students know the force on a charged particle in an electric field is qE, where E is the electric field at the position of the particle and q is the charge of the particle.
- Students know how to calculate the electric field resulting from a point charge.
- Students know static electric fields have as their source some arrangement of electric charges.

Radioactivity and Nuclear Phenomena

7. Radioactivity arises in the complex interaction of the strong nuclear, weak nuclear, and electromagnetic forces within the atomic nucleus. Nuclear phenomena have implication and applications to power generation, weaponry and public policy. As a basis for understanding this concept:

    - Students know how the terms and identify the characteristics of alpha, beta and gamma radiation.
    - Students know the terms and can explain the processes of fusion and fission.
    - Students know half life of a material is the time until half of the material has radioactively decayed.
    - Students know the release of alpha and beta particles causes the emitting nucleus to become a new element.
    - Students are aware of and can participate in the public policy debates regarding nuclear fuel, power and weapons.