

Students will be able to:

MOTION AND FORCES

- Compare and contrast vector quantities (*displacement, velocity, acceleration, force, linear momentum*) and scalar quantities (*distance, speed, energy, mass, work*).
- Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.
- 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.
- Interpret and apply Newton's three laws of motion.
- 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 objects.
- Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.
- Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.
- Describe conceptually the forces involved in circular motion.
- Interpret and provide examples that illustrate the law of conservation of energy.
- Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.
- Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.
- Describe both qualitatively and quantitatively the concept of power as work done per unit time.
- 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.

Students will be able to:

HEAT AND HEAT TRANSFER

- Explain how heat energy is transferred by convection, conduction, and radiation.
- Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.
- 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 between evaporation, condensation, cooling, and warming.
- 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.

Students will be able to:

WAVES AND RADIATION

- Describe the measurable properties of waves (*velocity, frequency, wavelength, amplitude, period*) and explain the relationships among them. Recognize examples of simple harmonic motion.
- Distinguish between mechanical and electromagnetic waves.
- Distinguish between the two types of mechanical waves, transverse and longitudinal.
- Describe qualitatively the basic principles of reflection and refraction of waves.
- Recognize that mechanical waves generally move faster through a solid than through a liquid and faster through a liquid than through a gas.
- Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler effect).
- Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.
- 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.

Students will be able to:

ELECTROMAGNETISM

- 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.
- Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's Law).
- 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.
- Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb's Law).
- 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.
- 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.