Physics

UNIT I: One Dimensional Motion and Analytical Techniques

Goal 1. The student will demonstrate the ability to carry out effective scientific investigations, analyze data, communicate results, and apply results to explain phenomena occurring outside the laboratory.

Objectives - The student will be able to:

a. Modify or affirm preexisting scientific conceptions through experimentation and using other evidence.
b. Use laboratory equipment properly.
c. Identify the independent and dependent variables in any experiment.
d. Graph data properly using axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, and an appropriate title.
e. Identify trends and sources of error using class data.
f. Analyze data by re-expressing data to determine the correct proportional relationship among variables, determining the value, units, and physical significance of the slope of the graph, and writing the equation derived from the analysis.
g. Predict and explain everyday phenomena using equations and graphs derived from data.

Goal 2. The student will demonstrate the ability to apply appropriate mathematical processes to solving problems.

Objectives - The student will be able to:

a. Use math skills, including unit conversions, manipulating and solving algebraic equations, scientific notation, and proportional relationships.
b. Use computers or graphing calculators to perform calculations for tables and graphs.
c. Solve problems methodically by making a diagram of the problem, identifying known and unknown quantities, identifying appropriate equations, and judging the reasonableness of an answer.

Goal 3. The student will demonstrate the ability to define, describe, calculate, and differentiate among position, displacement, speed, velocity, and acceleration.

Objectives - The student will be able to:

a. Define position as a signed number relative to an origin.
b. Define and calculate displacement (Δx) as the change in position of an object.
c. Identify the frame of reference used in any problem.
d. Define and calculate speed as the distance traveled divided by the elapsed time.
e. Define and calculate velocity as the change in position divided by the elapsed time.
f. Identify cases where average speed does not equal average velocity.
g. Describe a situation when the velocity is negative.

h. Define and calculate acceleration as the change in velocity divided by the elapsed time.
i. Describe how the physics definition of acceleration differs from the everyday definition of acceleration.
j. Interpret position versus time and velocity versus time graphs for motion at constant velocity and for motion at constant acceleration.
k. Solve motion problems using the equations, $x = x_0 + v_0t + (1/2)at^2$ and $v = v_0 + at$.

UNIT II: Force, Two-Dimensional Motion, and Gravity

Goal 1. The student will demonstrate the ability to state and apply Newton's three laws of motion.

Objectives - The student will be able to:

a. Explain that objects change their motion only when a net force is applied.
b. Apply the relationship, $a = F/m$, to physical situations in order to explain qualitatively and quantitatively how any one variable is affected by a change in another.
c. Use $a = F/m$ in conjunction with motion equations to solve problems involving motion in one dimension.
d. Explain that force is not something that an object "has", but is characteristic of the action between objects.
e. Explain that when one object applies a force to a second object, the second object simultaneously applies an equal and opposite force to the first object.

Goal 2. The student will demonstrate the ability to apply vector concepts and vector math to appropriate physical situations encountered throughout the course.

Objectives - The student will be able to:

a. Identify scalar and vector quantities.
b. Perform vector addition geometrically.
c. Determine the components of a vector using a geometric method.
d. Apply vector concepts to physical situations involving forces, projectile motion, and circular motion.
e. Identify and sketch forces acting on an object and determine the net force on the object using geometric vector addition.

Goal 3. The student will demonstrate the ability to describe the path of a projectile using motion equations and vector components.

Objectives - The student will be able to:

a. Identify a projectile as an object which has been launched and whose motion is affected only by gravity (ignoring air resistance).
b. Analyze the motion of the projectile by breaking its velocity and acceleration vectors into vertical and horizontal components.
c. Apply motion equations ($x = x_0 + v_{0x}t + (1/2)a_xt^2$ and $y = y_0 + v_{0y}t + (1/2)a_yt^2$) to solve projectile problems where the projectile has been launched horizontally.

Goal 4. **The student will demonstrate the ability to analyze and explain uniform circular motion.**

Objectives - The student will be able to:

a. Identify uniform circular motion.
b. Identify the type of force supplying the centripetal force that acts on any object in uniform circular motion.
c. Identify a centrifugal force as a fictitious force and explain how it results from an accelerated frame of reference.
d. Determine the directions of the velocity, acceleration, and net force vectors for an object in uniform circular motion.

Goal 5. **The student will demonstrate the ability to describe the law of universal gravitation.**

Objectives - The student will be able to:

a. Apply the proportional relationship of the law of universal gravitation, $F = Gm_1m_2/d^2$.
b. Explain why a spaceship in a stable circular orbit is in free fall and why a person in that spaceship experiences weightlessness.
c. Use Newton's second law and the law of universal gravitation to show why all objects near the surface of the earth fall with the same constant acceleration.

UNIT III: Energy and Momentum

Goal 1. **The student will demonstrate the ability to apply the concepts of momentum, impulse, conservation, and system to describe and numerically solve simple collision and explosion problems.**

Objectives - The student will be able to:

a. Calculate the momentum ($p = mv$) of an object.
b. Define and calculate impulse ($F\Delta t$) and apply it in the relationship, $F\Delta t = m\Delta v$.
c. Use the concept of impulse to explain and demonstrate mathematically why it is safer in a collision to take a longer time to come to a stop.
d. Analyze a problem and choose a system to determine if the forces are internal or external to that system.
e. Explain that a conserved quantity is a quantity that remains numerically constant.
f. Define and identify situations involving elastic and inelastic collisions and explosions.
g. State the law of conservation of momentum and use it to solve one -dimensional explosion and collision problems using the equation, $m_1v_1+m_2v_2 = m_1v_1'+m_2v_2'$.

Goal 2. **The student will demonstrate the ability to explain the relationships between work and energy.**

Objectives - The student will be able to:

a. Define energy in terms of work.

b. Calculate work ($W = Fd$) and illustrate that simple machines do not decrease work, rather, they decrease application force by increasing the distance that the force is applied.
c. Define and calculate kinetic energy ($KE = (1/2)mv^2$), and gravitational potential energy ($PE = mgh$).
d. State and apply the relationship that work done with no opposing force equals the change in kinetic energy.
e. State and apply the relationship that work done against gravity equals the change in gravitational potential energy.

Goal 3. The student will demonstrate the ability to discuss how energy in a system is transferred from one form to another or from one object to another, and use the conservation of energy to solve simple problems.

Objectives - The student will be able to:
a. Define and calculate mechanical energy as the sum of the kinetic and potential energy.
b. Identify the different forms of energy in simple systems such as a swinging pendulum or a car on a frictionless roller coaster.
c. Describe the law of conservation of energy for a system and apply it to problems where friction and air resistance are ignored.

UNIT IV: Electricity and Magnetism

Goal 1. The student will demonstrate the ability to identify kinds of electric charges, analyze interactions between two charged objects, and describe electric fields.

Objectives - The student will be able to:
a. Identify two kinds of electric charges and describe the interaction of like and unlike charges.
b. Describe the acquisition of net charge in terms of the gain or loss of electrons by friction, conduction, and induction, and explain that connecting objects to the ground discharges them.
c. Explain why an electrically charged object can attract an electrically neutral object.
d. Differentiate between conducting and insulating materials in terms of the ease that electrons flow in them.
e. Identify and apply the proportional relationships involved in Coulomb's law of electric force. ($F = kq_1q_2/d^2$)
f. Explain that the space around a charge is altered by the presence of the charge, producing an electric field in that space.
g. Explain that the direction of an electric field at any point is the direction of the net force on a test charge at that point.
h. Identify characteristic field line patterns for simple charge configurations, and use the field lines to determine the relative strength and direction of the electric field.

Goal 2. The student will demonstrate the ability to describe an analogy between water flowing through pipes and charge flowing through circuits.

Objectives - The student will be able to:

a. Describe the concepts in an electrical circuit including electric potential energy, electric potential, voltage, current, and resistance.
b. Use each concept to explain the flow of charge through a simple circuit and to illustrate the electric circuit/water analogy.

Goal 3. The student will demonstrate the ability to describe the characteristics of simple series and parallel circuits in terms of voltage, current, and resistance.

Objectives - The student will be able to:

a. Use Ohm's law ($V = IR$) to calculate circuit variables.
b. Explain that current is not "used up" in an electric circuit, rather, the electric potential energy of a charge is converted to heat energy as the charge flows through a resistor.
c. Identify the characteristics of simple series circuits including that the total resistance is equal to the sum of the resistances of the resistors ($R_T = R_1 + R_2 + ...$), the current is constant throughout the circuit, and the sum of the voltages across the resistors equals the voltage across the voltage source.
d. Identify the characteristics of simple parallel circuits including the inverse of the total resistance is equal to the sum of the inverses of the resistors ($1/R_T = 1/R_1 + 1/R_2 ...$), the voltage across each resistor is the same as the voltage source, and the sum of the currents in the branches equals the current output by the voltage source.
e. Explain why houses are wired in parallel and describe short circuits and the function of circuit breakers.

Goal 4. The student will demonstrate the ability to apply the concepts of power and energy in analyzing electrical circuits.

Objectives - The student will be able to:

a. Define power as the amount of energy transferred (work) divided by the elapsed time ($P = W/t$).
b. Define electrical power as the product of voltage and current ($P = VI$) and apply this to simple circuits.

Goal 5. The student will demonstrate the ability to describe the causes of magnetism, the interaction of magnets, and electromagnetic effects.

Objectives - The student will be able to:

a. Identify the fundamental cause of magnetism as the movement of charged particles with reference to electron spin, magnetic domains, and electric currents.
b. Explain that the space around a magnet is altered by the presence of the magnet producing a magnetic field.
c. Identify the characteristic field lines for simple magnetic configurations and for a current-carrying wire, using the field lines to determine the relative strength and the direction of the magnetic field.

d. Illustrate how a motor works by using a simplified diagram of a motor and describing that a magnetic field exerts a force on a current-carrying wire.
e. Illustrate how a generator works by using a simplified diagram and describing that a changing magnetic field inside a coil of wire induces an electric current in the coil of wire.

UNIT V: Waves

Goal 1. The student will demonstrate the ability to describe common forms of waves in terms of basic wave characteristics and discuss the transportation and transformation of wave energy.

Objectives - The student will be able to:

a. Describe the motion of the wave and of the wave medium for transverse and longitudinal waves.
b. Define wave characteristics including amplitude, wavelength (λ), and frequency (f).
c. Solve problems using the wave equation ($v = f\lambda$).
d. Cite examples of the transportation of energy in waveform and describe that wave energy can be converted to other forms of energy.

Goal 2: The student will demonstrate the ability to explain wave behavior including reflection, refraction, diffraction, interference, and the Doppler Effect.

Objectives - The student will be able to:

a. Sketch and describe how wave fronts reflect off of plane and concave barriers.
b. Sketch and describe how wave fronts refract when crossing a boundary, how the change in wave speed at the boundary produces refraction, and how refraction is affected by the wavelength of the wave.
c. Sketch and describe how the crests and troughs of two transverse waves can interfere (add or subtract) while passing through one another, and produce a pattern by two in-phase point sources.
d. Sketch and describe how wave fronts are diffracted when traveling through small apertures, and explain how diffraction varies with wavelength.
e. Illustrate that the wavelength of an approaching or receding wave source is different from the wavelength of a stationary wave source (i.e., explain the Doppler Effect).