eScience Labs LLC

More Than An Experiment, An Experience

Introductory Physics

Concepts and Experiments

Lab 1: The Scientific Method

Time: ½ hour

Concepts to explore: "What is a lab report?", "parts of a lab report", and "how to write a lab report".

Experiments: There are no experiments in this lab, as it is an introduction to the scientific method. However, this lab includes several critical thinking activities (scattered throughout the reading) that test student knowledge of the scientific method. No materials are required.

Lab 2: Writing a Lab Report

Time: ½ hour

Concepts to explore: Testable observations, hypothesis, null hypothesis, experimental approach, variables, control, and data collection.

Experiments:

Experiment 1: Design an Experiment

- Students design an experiment using their knowledge of the scientific method. Students then write a formal lab report to present their experimental information.

Lab 3: Measurements

Time: ½ hour

Concepts to explore: Units and unit conversion, accuracy vs. precision, scientific notation, significant digits, and calculation accuracy.

Experiments:

Experiment 1:

- Students complete activities that require them to determine significant digits, accuracy and precision, scientific notation, and percent error.

Lab 4: Types of Force

Time: 1 hour

Concepts to explore: Kinematics, types of forces, velocity, acceleration, balanced/unbalanced forces, free body diagrams, net force, and equilibrium.

Experiments:

Experiment 1: Friction

- Students demonstrate the relationship between the normal force and the force of friction.

Experiment 2: Velocity and Air-resistance

- Students experiment with air resistance and explore how air resistance can work against the force of gravity.

Lab 5: Newton's Laws

Time: 1 hour

Concepts to explore: Newton's First Law, weight vs. mass, inertia, Newton's Second Law, and Newton's Third Law.

Experiments:

Experiment 1: Newton's First Law

- Students perform a simple activity that demonstrates how water inside a bowl reacts to changes in motion.

Experiment 2: Unbalanced Forces – Newton's Second Law

- Students utilize a pulley system to study unbalanced forces to understand Newton's Second Law.

Experiment 3: Action/Reaction Pairs

- Students explore action/reaction pairs to understand the application of Newton's Third Law.

Experiment 4: Newton's Third Law

- Students investigate Newton's Third Law by sending a deflating balloon across a zip line.

Lab 6: Linear Motion

Time: 1 hour

Concepts to explore: Free fall, acceleration due to gravity, linear kinematic equations, and graphing motion.

Experiments:

Experiment 1: Free Fall

- Students study the effects of free fall using water and objects in a cup.

Experiment 2: Distance of Free Fall

- Students explore the distance of free fall during equal time intervals using hex nuts tied to a string.

Experiment 3: Graphing Linear Motion

- Students interpret motion graphs.

Lab 7: Projectile Motion

Time: 1 hour

Concepts to explore: Scalars vs. vectors, projectiles, and parabolic trajectory.

Experiments:

Experiment 1: Calculating Distance Traveled by a Projectile

- Students predict the range of a projectile set in motion.

Experiment 2: Squeeze Rocket Projectiles

- Students observe the distance a projectile will travel when the launch angle is changed.

Lab 8: Circular Motion

Time: 1 hour

Concepts to explore: Uniform circular motion, rotation vs. revolution, angular velocity, tangential velocity, centripetal force, and centrifugal "force".

Experiments:

Experiment 1: Balancing the Centripetal Force

- Students investigate the multidirectional nature of centripetal force and how the radius affects the period of rotation.

Lab 9: Center of Mass

Time: 1 hour

Concepts Explored: Center of mass, center of gravity, and stability.

Experiments:
Experiment 1: Identifying the Center of Mass
- Students hypothesize where the center of mass of a set of pictured objects is located.

Experiment 2: Stability Part 1
- Students test the stability of a stack of blocks as the angle of the surface it rest upon gradually increases, all while monitoring the position of the center of mass.

Experiment 3: Stability Part 2
- Students continue to explore the relationship between center of mass and stability.

Experiment 4: Irregular Shapes
- Students create an irregular shape from cardboard, and then experimentally find the center of mass.

Lab 10: Gravity

Time: 1 hour

Concepts Explored: Inverse square law, Newton's Universal Law of Gravitation, universal gravitational constant, and 'G'.

Experiments:
Experiment 1: Falling in a Gravitational Field
- Students experimentally convince themselves that all objects fall at the same rate.

Experiment 2: Inverse Square Law
- Students explore the concept of gravity diminishing greatly as distance increases with the use of a flashlight.

Lab 11: Energy

Time: 1 hour

Concepts Explored: Energy, kinetic energy, potential energy, work, power, and conservation of energy.

Experiments:
Experiment 1: Roller Coaster Physics
- Students examine the path of a roller coaster and describe the kind of energy at work.

Experiment 2: Popper Physics
- Students calculate the potential and kinetic energy of a popper toy experimentally.

Lab 12: Momentum

Time: 1- 1 ½ hours

Concepts Explored: Momentum, impulse, conservation of momentum, and elastic vs. inelastic collisions.

Experiments:
Experiment 1: Conservation of Momentum
- Students demonstrate transfers of momentum using marbles.

Experiment 2: Egg Drop
- Students create a crash bed using paper and tape that will prevent a falling egg from breaking upon impact.

Lab 13: Mechanical Advantage

Time: 1 hour

Concepts Explored: Machines, mechanical advantage, levers, inclines plane, wheel and axle, and pulleys.

Experiments:
Experiment 1: Levers
- Students study hot the force required to life a load using a lever varies as the length of the lever changes.

Experiment 2: Pulleys
- Students use pulleys to demonstrate how the simple machines can reduce the force required to lift something.

Lab 14: Exploring Matter

Time: 1- 1 ½ hours

Concepts Explored: Atoms, elements, the periodic table, molecules and compounds, and pressure.

Experiments:
Experiment 1: Active Atoms
- Students explore the effect of temperature on atom activity using food coloring with hot and cold water.

Experiment 2: Barometric Pressure
- Students construct a barometer and explore environmental pressure changes over 24 hours.

Experiment 3: Marshmallow Madness
- Students investigate the alterations of a marshmallow when exposed to gas pressure changes.

Lab 15: Properties of Solids

Time: 1- 1 ½ hours

Concepts Explored: Structure of solid materials, forces within solids, tensile, compressive and shear strength, Hooke's Law and Young's Modulus, stiffness, toughness, and hardness.

Experiments:
Experiment 1: Growing Crystals
- Students grow their own crystals and compare the structure of two types made with different chemicals.

Experiment 2: Building Bridges
- Students design and construct a bridge and test its strength.

Experiment 3: Oobleck
- Students explore the material properties of several materials, including modeling clay and a cornstarch/water mixture.

Lab 16: Properties of Fluids

Time: 1 hour

Concepts Explored: Pressure, buoyancy, density, Archimedes Principle, Bernoulli's Principle, and viscosity.

Experiments:
Experiment 1: Effects of Density
- Students create a density column and observe the vertical arrangement of several objects.

Experiment 2: Exploring Fluid Properties

- Students experiment with Bernoulli's principle, the Coanda effect, and lift.

Experiment 3: Bernoulli's Principle
- Students perform several demonstrations that explore the effects of moving air.

Experiment 4: Buoyant Force and Archimedes' Principle
- Students create clay boats and explore buoyancy in tap and salt water conditions.

Lab 17: Temperature and Heat

Time: 1 hour

Concepts Explored: Temperature vs. heat, absolute zero, internal energy, thermal equilibrium, thermal expansion, and specific heat.

Experiments:

Experiment 1: Thermometer Lab
- Students create a thermometer to explore liquid expansion.

Experiment 2: Thermal Expansion and Contraction
- Students investigate how temperature affects the length of a rubber band.

Experiment 3: Specific Heat
- Students create a calorimeter to test the specific heat of various objects.

Lab 18: Thermal Energy

Time: ¾ hour

Concepts Explored: Ideal Gas Law, The First Law of Thermodynamics, The Second Law of Thermodynamics, entropy, and heat engines.

Experiments:

Experiment 1: Can Crusher
- Students investigate the effects of sudden temperature changes on an empty aluminum can.

Experiment 2: Charles's Law Experiments
- Students use Charles's Law to approximate absolute zero with the use of a sealable syringe placed in several different temperature conditions.

Experiment 3: Entropy Simulation
- Students explore ordered systems moving to disorder and the irreversibility of thermal processes with some pennies in a box.

Lab 19: Heat Transfer

Time: 1- 1 ½ hours

Concepts Explored: Conduction, convection, and radiation.

Experiments:

Experiment 1: Conduction
- Students explore how different materials conduct heat.

Experiment 2: Convection Currents
- Students investigate convection currents by mixing colored water of different temperatures.

Experiment 3: Combined Heat Transfer
- Students experiment with different methods that can limit heat transfer between the environment and a sample of ice.

Lab 20: Phase Changes

Time: 1 hour

Concepts Explored: Boiling, freezing, evaporation, condensation, sublimation, and phase diagram.

Experiments:
Experiment 1: Freezing and Melting
- Students investigate how salt affects the melting and freezing points of water.

Experiment 2: Clouds in a Bottle
- Students form clouds in a plastic bottle.

Lab 21: Properties of Waves

Time: 45 minutes -1 hour

Concepts Explored: Wave motion, types of waves, superposition, standing waves, and resonance.

Experiments:
Experiment 1: Slinky Waves
- Students experiment with a Slinky to understand wave speed, reflection, and interference in transverse and longitudinal waves.

Experiment 2: Doppler Effect
- Students use a cork and water to visualize the effects of moving sources on wave frequency.

Lab 22: Light

Time: 45 minutes - 1 hour

Concepts Explored: Electromagnetic waves, speed of light, reflection and refraction, and mirrors and lenses.

Experiments:
Experiment 1: Ray Diagrams
- Students create ray diagrams for a concave mirror and convex lenses.

Experiment 2: Exploring Mirrors
- Students explore concave and convex mirrors and real and virtual images.

Experiment 3: Exploring Lenses
- Students investigate the properties of concave and convex lenses.

Lab 23: Color

Time: 1 hour

Concepts Explored: Visible spectrum, white light, prisms, primary, secondary, and complimentary colors, and reflection and transmission.

Experiments:
Experiment 1: Prisms
- Students experiment with prisms and the separation of white light.

Experiment 2: Color Reflection
- Students answer questions about color appearances under various conditions.

Lab 24: Sound

Time: 45 minutes – 1 hour

Concepts Explored: Sound waves, speed of sound, pitch, loudness vs. intensity, beats, and resonance.

Experiments:
Experiment 1: String Vibrations
- Students study how sound travels along a string.

Experiment 2: Resonance in Bottles
- Students investigate how water filled bottles create different pitches when struck with a metal object or when one blows across the top of the bottle.

Lab 25: Electric Fields

Time: 45 minutes – 1 hour

Concepts Explored: Charge, electric field, field lines, and electric energy storage.

Experiments:
Experiment 1: Static Materials
- Students investigate static electricity using an electrostatics kit containing different plastics, fabrics, and pith balls.

Experiment 2: Static Balloons
- Students play with balloons to understand static electricity.

Experiment 3: Simple Electroscope
- Students create an electroscope and explore static electricity.

Lab 26: Electric Current

Time: 45 minutes – 1 hour

Concepts Explored: Current, voltage, electric resistance, Ohm's Law, electrons, and current.

Experiments:
Experiment 1: Electric Current and Conduction
- Students explore electrical conductivity of different materials using Snap Circuits®.

Experiment 2: Electric Resistance
- Students study the role of resistors in a circuit using Snap Circuits®.

Lab 27: Electric Circuits

Time: 45 minutes – 1 hour

Concepts Explored: Open and closed circuits, series circuits, parallel circuits, and resistors.

Experiments:
Experiment 1: Resistors in Series and Parallel
- Students investigate the activity of different types of circuits using Snap Circuits®.

Experiment 2: LEDs in Series and Parallel
- Students investigate the activity of different types of circuits using Snap Circuits®.

Lab 28: Magnetic Fields

Time: 45 minutes – 1 hour

Concepts Explored: Magnetic fields, magnetic poles, electricity and magnetism, and the right hand rule.

Experiments:
Experiment 1: Exploring Magnets
- Students experiment with ring magnets.

Experiment 2: Magnetic Field Lines
- Students use magnets and iron filings to visualize magnetic fields.

Experiment 3: Building an Electromagnet
- Students create and experiment with an electromagnet using magnet wire and a battery.

Lab 29: Electromagnetic Induction

Time: 1 hour

Concepts Explored: Faraday's Law, electromagnetic induction, motors, generators, and transformers.

Experiments:
Experiment 1: Simple Electric Motor
- Students create and experiment with a simple motor using magnet wire, magnets, and a battery.