

Topic	Lesson	Objectives
Introduction to Physics		
	Mathematics and Physics	
		Demonstrate scientific methods.
		Use the metric system.
		Evaluate answers using dimensional analysis.
		Perform arithmetic operations using scientific notation.
	Measurement	
		Distinguish between accuracy and precision.
		Determine the precision of measured quantities.
	The Language of Physics	
		Interpret data in tables and graphs, and recognize equations that summarize data.
		Distinguish between conventions for abbreviating units and quantities.
		Use dimensional analysis to check the validity of equations.
		Perform order-of-magnitude calculations.
Representing Motion		
	Picturing Motion	
		Draw motion diagrams to describe motion.
		Develop a particle model to represent a moving object.
	Where and When?	
		Define coordinate systems for motion problems.
		Recognize that the chosen coordinate system affects the signs of the objects' positions.
		Define displacement.
		Determine a time interval.
		Use a motion diagram to answer questions about an object's position or displacement.
	Position and Time Graphs	
		Develop position-time graphs for moving objects.
		Use a position-time graph to interpret an object's position or displacement.
		Make motion diagrams, pictorial representations, and position-time graphs that are equivalent representations describing an object's motion.
	How Fast?	
		Define velocity.
		Differentiate between speed and velocity.
		Create pictorial, physical, and mathematical models of motion problems.

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Accelerated Motion		
	Acceleration	
		Define acceleration.
		Relate velocity and acceleration to the motion of an object.
		Create velocity-time graphs.
	Motion with Constant Acceleration	
		Interpret position-time graphs for motion with constant acceleration.
		Determine mathematical relationships among position, velocity, acceleration, and time.
		Apply graphical and mathematical relationships to solve constant-acceleration problems.
	Free Fall	
		Define acceleration due to gravity.
		Solve problems involving objects in free fall.
Two-Dimensional Motion and Vectors		
	Introduction to Vectors	
		Distinguish between a scalar and a vector.
		Add and subtract vectors by using the graphical method.
		Multiply and divide vectors by scalars.
	Vector Operations	
		Identify appropriate coordinate systems for solving problems with vectors.
		Apply the Pythagorean theorem and tangent function to calculate the magnitude and direction of a resultant vector.
		Resolve vectors into components using the sine and cosine functions.
		Add vectors that are not perpendicular.
	Projectile Motion	
		Recognize examples of projectile motion.
		Describe the path of a projectile as a parabola.
		Resolve vectors into their components and apply the kinematic equations to solve problems involving projectile motion.
	Relative Motion	
		Describe situations in terms of frame of reference.
		Solve problems involving relative velocity.
Forces and Laws of Motion		
	Changes in Motion	
		Describe how force affects the motion of an object.
		Interpret and construct free-body diagrams.

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	Newton's First Law	
		Explain the relationship between the motion of an object and the net external force acting on the object.
		Determine the net external force on an object.
		Calculate the force required to bring an object into equilibrium.
	Newton's Second and Third Laws	
		Describe an object's acceleration in terms of its mass and the net force acting on it.
		Predict the direction and magnitude of the acceleration caused by a known net force.
		Identify action-reaction pairs.
	Everyday Forces	
		Explain the difference between mass and weight.
		Find the direction and magnitude of normal forces.
		Describe air resistance as a form of friction.
		Use coefficients of friction to calculate frictional force.
Work and Energy		
	Work	
		Recognize the difference between the scientific and ordinary definitions of work.
		Define work by relating it to force and displacement.
		Identify where work is being performed in a variety of situations.
		Calculate the net work done when many forces are applied to an object.
	Energy	
		Identify several forms of energy.
		Calculate kinetic energy for an object.
		Apply the work-kinetic energy theorem to solve problems.
		Distinguish between kinetic and potential energy.
		Classify different types of potential energy.
		Calculate the potential energy associated with an object's position.
	Conservation of Energy	
		Identify situations in which conservation of mechanical energy is valid.
		Recognize the forms that conserved energy can take.
		Solve problems using conservation of mechanical energy.
	Power	
		Relate the concepts of energy, time and power.
		Calculate power in two different ways.
		Explain the effect of machines on work and power.

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Rotational Motion		
	Describing Rotational Motion	
		Describe angular displacement.
		Calculate angular velocity.
		Calculate angular acceleration.
		Solve problems involving rotational motion.
	Rotational Dynamics	
		Describe torque and the factors that determine it.
		Calculate net torque.
		Calculate the moment of inertia.
	Equilibrium	
		Define center of mass.
		Explain how the location of the center of mass affects the stability of an object.
		Define the conditions for equilibrium.
		Describe how rotating frames of reference give rise to apparent forces.
Momentum and Its Conservation		
	Impulse and Momentum	
		Define the momentum of an object.
		Determine the impulse given to an object.
		Define the angular momentum of an object.
	Conservation of Momentum	
		Relate Newton's third law to conservation of momentum in collisions and explosions.
		Recognize the conditions under which momentum is conserved.
		Solve conservation of momentum problems in two dimensions.
Circular Motion and Gravitation		
	Circular Motion	
		Solve problems involving centripetal accelerations.
		Solved problems involving centripetal force.
		Explain how the apparent existence of an outward force in circular motion can be explained as inertia resisting the centripetal force.
	Newton's Law of Universal Gravitation	
		Explain how Newton's law of universal gravitation accounts for various phenomena, including satellite and planetary orbits, falling objects, and the tides.
		Apply Newton's law of universal gravitation to solve problems.

Topic	Lesson	Objectives
	Motion in Space	
		Describe Kepler's laws of planetary motion.
		Relate Newton's mathematical analysis of gravitational force to the elliptical planetary orbits proposed by Kepler.
		Solve problems involving orbital speed and period.
	Torque and Simple Machines	
		Distinguish between torque and force.
		Calculate the magnitude of torque on an object.
		Identify the six types of simple machines.
		Calculate the mechanical advantage of a simple machine.
Fluid Mechanics		
	Fluids and Buoyant Force	
		Define a fluid.
		Distinguish a gas from a liquid.
		Determine the magnitude of the buoyant force exerted on a floating object or a submerged object.
		Explain why some objects float and some object sink.
	Fluid Pressure	
		Calculate the pressure exerted by a fluid.
		Calculate how pressure varies with depth in a fluid.
	Fluids in Motion	
		Examine the motion of a fluid using the continuity equation.
		Recognize the effects of Bernoulli's principle on fluid motion.
Thermal Energy		
	Temperature and Thermal Energy	
		Describe thermal energy and compare it to potential and kinetic energies.
		Distinguish temperature from thermal energy.
		Define specific heat and calculate heat transfer.
	Changes of State and the Laws of Thermodynamics	
		Define heats of fusion and vaporization.
		State the first and second laws of thermodynamics.
		Distinguish between heat and work.
		Define entropy.

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Vibrations and Waves		
	Periodic Motion	
		Describe the force in an elastic spring.
		Determine the energy stored in an elastic spring.
		Compare simple harmonic motion and the motion of a pendulum.
	Wave Properties	
		Identify how waves transfer energy without transferring matter.
		Contrast transverse and longitudinal waves.
		Relate wave speed, wavelength, and frequency.
	Wave Behavior	
		Relate a wave's speed to the medium in which the wave travels.
		Describe how waves are reflected and refracted at boundaries between media.
		Apply the principle of superposition to the phenomenon of interference.
Sound		
	Properties and Detection of Sound	
		Demonstrate the properties that sound shares with other waves.
		Relate the physical properties of sound waves to our perception of sound.
		Identify some applications of the Doppler effect.
	The Physics of Music	
		Describe the origin of sound.
		Demonstrate an understanding of resonance, especially as applied to air columns and strings.
		Explain why there are variations in sound among instruments and among voices.
Light and Reflection		
	Characteristics of Light	
		Identify the components of the electromagnetic spectrum.
		Calculate the frequency or wavelength of electromagnetic radiation. Recognize that light has a finite speed.
		Describe how the brightness of a light source is affected by distance.
	Flat Mirrors	
		Distinguish between specular and diffuse reflection of light.
		Apply the law of reflection for flat mirrors.
		Describe the nature of images formed by flat mirrors.

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	Curved Mirrors	
		Calculate distances and focal lengths using the mirror equation for concave and convex spherical mirrors.
		Draw ray diagrams to find the image distance and magnification for concave and convex spherical mirrors.
		Distinguish between real and virtual images.
		Describe how parabolic mirrors differ from spherical mirrors.
	Color and Polarization	
		Recognize how additive colors affect the color of light.
		Recognize how pigments affect the color of reflected light.
		Explain how linearly polarized light is formed and detected.
Refraction		
	Refraction	
		Recognize situations in which refraction will occur.
		Identify which direction light will bend when it passes from one medium to another.
		Solve problems using Snell's law.
	Thin Lenses	
		Use ray diagrams to find the position of an image produced by a converging or diverging lens, and identify the image as real or virtual.
		Solve problems using the thin-lens equation.
		Calculate the magnification of lenses.
		Describe the positioning of lenses in compound microscopes and refracting telescopes.
	Optical Phenomena	
		Predict whether light will be refracted or undergo total internal reflection.
		Recognize atmospheric conditions that cause refraction.
		Explain dispersion and phenomena such as rainbows in terms of the relationship between the index of refraction and the wavelength.
Interference and Diffraction		
	Interference	
		Describe how light waves interfere with each other to produce bright and dark fringes.
		Identify the conditions required for interference to occur.
		Predict the location of interference fringes using the equation for double-slit interference.
	Diffraction	
		Describe how light waves bend around obstacles and produce bright and dark fringes.
		Calculate the positions of fringes for a diffraction grating.
		Describe how diffraction determines an optical instrument's ability to resolve images.

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	Lasers	
		Describe the properties of laser light.
		Explain how laser light has particular advantages in certain applications.
Static Electricity and Fields		
	Electric Charge	
		Demonstrate that charged objects exert forces, both attractive and repulsive.
		Recognize that charging is the separation, not the creation of electric charges.
		Describe the differences between conductors and insulators.
	Electric Force	
		Summarize the relationships between electric forces, charges, and distance.
		Explain how to charge objects by conduction and induction.
		Develop a model of how charged objects can attract a neutral object.
		Apply Coulomb's law to problems in one and two dimensions.
	Creating and Measuring Electric Fields	
		Define an electric field.
		Solve problems relating to charge, electric fields, and forces.
		Diagram electric field lines.
	Applications of Electric Fields	
		Define electric potential differences.
		Calculate potential difference from the work required to move a charge.
		Describe how charges are distributed on solid and hollow conductors.
		Solve problems pertaining to capacitance.
Electricity Currents and Circuits		
	Current and Circuits	
		Describe conditions that create current in an electric circuit.
		Explain Ohm's law.
		Design closed circuits.
		Differentiate between power and energy in an electric circuit.
	Using Electric Energy	
		Explain how electric energy is converted into thermal energy.
		Explore ways to deliver electric energy to consumers near and far.
		Define kilowatt-hour.

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	Simple Circuits	
		Describe series and parallel circuits.
		Calculate currents, voltage drops, and equivalent resistances in series and parallel circuits.
	Applications of Circuits	
		Explain how fuses, circuit breakers, and ground-fault interrupters protect household wiring.
		Analyze and solve problems involving combined series-parallel circuits.
		Explain how voltmeters and ammeters are used in circuits.
Magnetism		
	Magnets and Magnetic Fields	
		For given situations, predict whether magnets will repel or attract each other.
		Describe the magnetic field around a permanent magnet.
		Describe the orientation of Earth's magnetic field.
	Magnetism from Electricity	
		Describe the magnetic field produced by current in a straight conductor and in a solenoid.
		Use the right-hand rule to determine the direction of the magnetic field in a current-carrying wire.
	Magnetic Force	
		Given the force on a charge in a magnetic field, determine the strength of the magnetic field.
		Use the right-hand rule to find the direction of the force on a charge moving through a magnetic field.
		Determine the magnitude and direction of the force on a wire carrying current in a magnetic field.
Electromagnetic Induction		
	Electricity from Magnetism	
		Recognize that relative motion between a conductor and a magnetic field induces an emf in the conductor.
		Describe how the change in the number of magnetic field lines through a circuit loop affects the induced electric current.
		Apply Lenz's law and Faraday's law of induction to solve problems involving induced emf and current.
	Generators, Motors, and Mutual Inductance	
		Describe how generators and motors operate. Explain the energy conversions that take place in generators and motors.
		Describe how mutual induction occurs in circuits.
	AC Circuits and Transformers	
		Distinguish between rms values and maximum values of current and potential difference. Solve problems involving rms and maximum values of current and emf for ac circuits.
		Apply the transformer equation to solve problems involving step-up and step-down transformers.

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	Electromagnetic Waves	
		Describe what electromagnetic waves are and how they are produced.
		Recognize that electricity and magnetism are two aspects of a single electromagnetic force.
		Explain how electromagnetic waves transfer energy.
		Describe various applications of electromagnetic waves.
Atomic Physics		
	Quantization of Energy	
		Explain how Planck resolved the ultraviolet catastrophe in blackbody radiation.
		Calculate energy of quanta using Planck's equation.
		Solve problems involving maximum kinetic energy, work function, and threshold frequency in the photoelectric effect.
	Models of the Atom	
		Explain the strengths and weaknesses of Rutherford's model of the atom.
		Recognize that each element has a unique emission and absorption spectrum.
		Explain atomic spectra using Bohr's model of the atom.
		Interpret energy-level diagrams.
	Quantum Mechanics	
		Recognize the dual nature of light and matter.
		Calculate the de Broglie wavelength of matter waves.
		Distinguish between classical ideas of measurement and Heisenberg's uncertainty principle.
		Describe the quantum-mechanical picture of the atom, including the electron cloud and probability waves.
Subatomic Physics		
	The Nucleus	
		Identify the properties of the nucleus of an atom.
		Explain why some nuclei are unstable.
		Calculate the binding energy of various nuclei.
	Nuclear Decay	
		Describe the three modes of nuclear decay.
		Predict the products of nuclear decay.
		Calculate the decay constant and the half-life of a radioactive substance.
	Nuclear Reactions	
		Distinguish between nuclear fission and nuclear fusion.
		Explain how a chain reaction is utilized by nuclear reactors.
		Compare fission and fusion reactors.

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	Particle Physics	
		Define the four fundamental interactions of nature.
		Identify the elementary particles that make up matter.
		Describe the standard model of the universe.