PHYSICS

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Overview

Physics is a vital science, which introduces students to universal laws which influence many of our experiences. Topics such as measurements, atomic structure, forms of energy, machines, laws of gravity and motion are a number of areas students will investigate.

Students will study how these laws govern everyday activities. In addition they will observe direct relationships between mathematics and science.

Careers Related to Physics

- Science
- Teacher-Engineer-Civil, Design, Mechanical, Electrical
- Physicist
- NASA Researchers
- Actuary
- Surveyor
- Air traffic controller
- Paramedic Trainee
- Chiropractor
- Audiologist
- Technician: Bio Medical Engineer
    - Electronic
    - X-Ray
    - Optical
    - Laser
    - CAT-Scan
- Astro Physicist
- Nuclear Physicist
- Elect5rician
- Geologist
- Pilot (aircraft)
- Architect
- Draftsman
- Chemist
- Oceanographer
- Auto Mechanic
- Laser Technician
- Pharmacist
- Nuclear Scientist
- Scientific Sales
- Radiologist (M.D.)
- Ophthalmologist (M.D.)
- Optometrist
- Optician
- Photographer
- Spectroscopist
- Vending Machines Repair
- Welder
- Meteorologist
- Power Plant Operations Trainee
- Broadcast Technician
- System Analyst

Contributors to Physics

1. Albert Einstein
2. Marie Curie
3. Isaac Newton
4. Ernest Rutherford
5. Thomas Edison
6. Henry Ford
7. Samuel Morse
8. Luis Walter Alvarez
9. Robert Goddard
10. An Wang
11. George Washington Carver
12. George Westinghouse
13. John Wheeler
14. Edward Teller
15. Enrico Teller
16. Stephen Hawking

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
I <u>What is Physics?</u> A. The Wanderers B. Galileo and Scientific Methods C. Mars in Recent Times **(1/2 class session)**	Physics is the study of matter and energy and their relationships. Physics is basic to all other sciences. Acknowledge of physics makes us better able to make decisions about questions related to science and technology. Much scientific work is done in groups in which people collaborate with one another.	Define Physics. Relate theory experiment, and applications to the role they play in physics research. Demonstrate that, while there is no single scientific method, there are common methods used by all scientists.	5.1 (A-2) (A-3) 5.2 (B-1) 5.4 (A-1)	<u>Text Lab:</u> Egg Drop Project <u>Pocket Lab:</u> Falling (1) <u>Lab Manual:</u> Bubble up 1-1

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II A Mathematical Toolkit A. Measures of Science **(1 class session)**	The meter, second, and Kilogram are the SI base units of length, time and mass, respectively. Derived units are combinations of base units. Prefixes are used to change SI units by powers of 10. The Method of converting one unit to another is called the factor label method.	Define the SI Standards of Measurement. Use common metric prefixes. Estimate measurements and solution to problems. Perform arithmetic operations using specific notation.	5.1 (A-1)	Text Lab: Mystery Plot Pocket Lab: How good is your eye? (2.1) How far around? (2.3) Lab Manual: Measuring Length 2-1 Measuring temperature 2-2

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B. Measurement uncertainties **(2 Class Sessions)**	All measurements are subject to some uncertainty. Precision is the degree of exactness with which a quantity is measured using a given instrument. Accuracy is the extent to which the measured and accepted values of a quantity agree. The last digit in a measurement is always an estimate.	Distinguish between accuracy and precision. Indicate the precision of measured quantities with significant digits. Perform arithmetic operations with significant digits.	5.1 (A-3) 5.3 (A-1) (B-1)	

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C. Visualizing Data **(2 Class Sessions)**	Data are plotted in graphical form to show the relationship between two variables. The independent variable is the variable that changes; plotted on the X- on horizontal axis. The dependent variable, which changes as a result of the changes made to the independent; plotted on the Y- on vertical axis. A linear relationship can be represented by the equation y= mx + b. The slope, m, of a straight-line graph is the vertical change (rise) divided by the horizontal change (run).	Graph the relationship between independent and dependent variables. Recognize linear and direct relationships and interpret the Slope of a curve. Recognize quadratic and inverse relationships.	5.3 (0-1)	

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	The graph of a quadratic relationship is a parabolic curve; represented by the equation $y= ax^2 +bx+c$ The graph of an inverse relationship between x and y is a hyperbolic curve; represented by the equation y= a/x.			

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III Motion A. Picture Motion **(2 Class Sessions)**	A motion diagram shows the position of an object at successive times. In the particle model, the object in the motion diagram is replaced by a series of single points. An operational definition defines a concept in terms of the process or operation used.	Draw and use motion diagrams to describe motion. Use a particle model to represent a moving object.	5.3	Text Lab: Notion of Motion Pocket Lab: Rolling along (3.2) Swinging (3.3) Lab Manual: Analyzing Motion 3-1

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B. Where and When? **(1 Class Session)**	While a scalar quantity has only magnitude, or size, a vector quantity has both magnitude and direction. A position vector is drawn from the origin of the coordinate system to the object. A displacement vector is drawn from the position of the moving object at an earlier time to its position at a later time. The distance is the length or magnitude of the displacement vector.	Choose coordinate systems for motion problems. Differentiate between scalar and vector quantities. Define a displacement vector and determine a time interval. Recognize how the chosen coordinate system affects the signs of vectors quantities.	5.3 (A-1)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
C. Velocity and Acceleration **(2 Class Sessions)**	Velocity and acceleration are defined in terms of the processes used to find them. Both are vector quantities with magnitude and direction. Use a motion diagram as a physical model to find the direction of the acceleration in each part of the problem.	Define velocity and acceleration operationally. Related the direction and magnitude of velocity and acceleration vectors to the motion of objects Create pictoral and physical models for solving motion problems.	5.3	

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IV Vector Addition A. Properties of Vectors. **(2 Class Sessions)**	Vectors are quantities that have both magnitude and direction. They can be represented graphically as arrows or algebraically as symbols. Vectors can be added graphically by placing the tail of one at the tip of the other and drawing the resultant from the tail of the first to the tip of the second. The sum of two or more vectors is the resultant vector. The Law of Cosines may be used to find the magnitude of the resultant of any two vectors. This simplifies to the Pythagorean Theorem if the vectors are at right angles.	Determine graphically the sum of two or more vectors. Solve problems of relative velocity.	5.3 (A-1) (B-1)	Text Lab: The Paper River Pocket Lab: Lady Bug (4.2) Lab Manual: Addition of Vector Forces 4-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	Vectors addition may be used to solve problems involving relative velocities.			

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B. Components of Vectors. **(3 Class Sessions)**	Placing vectors in a coordinate system that you have chosen makes it possible to decompose them into components along each of the chosen coordinate axes. The components of a vector are the projections of the component vectors. They are scalars and have signs, positive or negative, indicating their directions.	Establish a coordinate system in problems involving vector quantities. Use the process of resolution of vectors to find the components of vectors. Determine algebraically the sum of two or more vectors by adding the components of the vectors.	5.3 (A-1) (D-1)	

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V. Mathematical Model of Motion. A. Graphing Motion in the Dimension **(1 Class Session)**	Position-time graphs can be used to find the velocity and position of an object, and where and when two objects meet. A description of motion can be obtained by interpreting graphs, and graphs can be drawn from descriptions of motion.	Interpret graphs of position versus time for a moving object to determine the velocity of the object. Describe the information presented in graphs and draw graphs from descriptions of motion. Write equations that describe the position of an object moving at constant velocity.	5.3 (C-1) (D-1)	Text Lab: Ball and car race Pocket Lab: Uniform of Not (5.1) A Ball Race (5.2) Bowling Ball Displacement (5.2) Direction of Acceleration (5.3) Lab Manual: Acceleration Motion 5-1 Acceleration Due to Gravity 5-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Graphing Velocity in One Dimension. **(2 class sessions)**	Instantaneous velocity is the slope of the tangent to the curve on a position time graph. Velocity-time graphs can be used to determine the velocity of an object and the time when two objects have the same velocity. The area under the curve on a velocity-time graph is displacement.	Determine, from a graph of velocity versus time, the velocity of an object at a specified time. Interpret a *v-t* graph to find the time at which an object has a specific velocity. Calculate the displacement of an object from the area under a *v-t* curve.	5.3 (D-1)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
C. Acceleration **(2 Class Sessions)**	The acceleration of an object is the slope of the curve on a velocity-time graph. The slope of the tangent to the curve on a *v-t* graph is the instantaneous acceleration of the object. Velocity-time graphs and motion diagrams can be used to find the sign of the acceleration. Both graphs and equations can be used to find the velocity of an object undergoing constant acceleration.	Determine from the curves on a velocity-time graph both the constant and instantaneous acceleration. Determine the sign of acceleration using a *v-t* graph and a motion diagram. Calculate the velocity and the displacement of an object undergoing constant acceleration.	5.3 (D-1)	

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D. Free Fall **(2 Class Sessions)**	The magnitude of the acceleration due to gravity ($g = 9.80\ m/s^2$) is always a positive quantity. Motion equations can be used to solve problems involving freely falling objects.	Recognized the meaning of acceleration due to gravity. Define the magnitude of the acceleration due to gravity as a positive quantity and determine the sign of the acceleration relative to the chosen coordinate system. Use the motion equations to solve problems involving freely falling objects.	5.7 (A-3)	

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VI Forces A. Force and Motion **(2 class sessions)**	Forces are vector quantities, having both direction and magnitude. Newton's second law states that the acceleration of a system equals the net force on it divided by its mass. Newton's first law states that if, and only if, an object has no net force on it, then its velocity will not change. The inertia of an object is its resistance to changing velocity.	Define a force and differentiate between contact forces and long-range forces. Recognize the significant of Newton's second law of motion and use it to solve motion problems. Explain in the meaning of Newton's first law and describe an object in equilibrium.	5.2 (B-3) 5.7 (A-1) (A-3)	Text Lab: The Elevator Ride Pocket Lab: How Fair id forever? (6.1) Tug-of-War Challenge (6.1) Friction Depends on What? (6.2) Upside-Down Parachute (6.2) Stopping Forces (6.3) Lab Manual: Newton's Second Law 6-1 Friction 6-2 Pushes, Pulls and Vectors 6-3

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Using Newton's Laws. **(3 class sessions)**	The weight of an object depends upon the acceleration due to gravity and the mass of the object. The friction force acts when two surfaces touch. The friction force is proportional to the force pushing the surfaces together.	Describe how the weight and the mass of an object are related. Differentiate between the gravitational force weight and what is experienced as apparent weight. Define the friction force and distinguish between static and kinetic friction. Describe simple harmonic motion and explain how the acceleration due to gravity influences such motion.	5.3 (B-1) 5.7 (A-1) (B-3)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
C. Interaction Forces **(2 class sessions)**	An object undergoes simple harmonic motion if the net restoring force on it is directly proportional to the object displacement. All forces result from interaction between objects. Newton's third law states that the two forces are equal in magnitude but opposite in direction and act on different objects. Although there are many different forces they are all forms of the four fundamental forces.	Explain the meaning of interaction pairs of forces and how they are related by Newton's third law. List the four fundamental forces and illustrate the environment in which each can be observed. Explain the tension in ropes and strings in terms of Newton's third law.	5.7 (A-2) (A-S)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
VII Forces and Motion in two Dimensions A. Forces in two Dimensions **(2 class sessions)**	Determine the force that produces equilibrium when three forces act on an object. Analyze the motion of an object on an inclined plane with and without friction.	The force that must be exerted on an object in order to put in equilibrium is called the equilibrant. The equilibrant is found by finding the sum of all forces on an object, than applying a force with the same magnitude but opposite direction.	5.3 (B-1) 5.7 (A-1)	Text Lab: The Softball Throw Pocket Lab: Over the Edge (7.2) Where The Ball Bounces (7.2) Target Practice (7.3) Falling Sideways (7.3) Lab Manual: Projectile Motion 7-1 Range of a Projectile 7-2 Torques 7-3

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Projectile Motion **(3 class sessions)**	The vertical and horizontal motions of a projectile are independent. The range of a projectile depends upon the acceleration due to gravity and upon both components of the initial velocity.	Recognize that the vertical and horizontal motions of projectile are independent. Relate the height, time in the air, and initial vertical velocity of a projectile using its vertical motion, then determine the range. Explain how the shape of the trajectory of a moving object depends upon the frame of reference from which it is observed.	5.7 (A-1)	

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C. Circular Motion **(2 class sessions)**	An object moving in a circle at constant speed is accelerating toward the center of the circle (centripetal acceleration). Centripetal acceleration depends directly on the square of the object's speed and inversely on the radius of the circle. A force must be exerted in the centripetal direction to cause that acceleration. The torque that changes the velocity of circular motion is proportional to the force applied and the lever arm.	Explain the acceleration of an object moving in a circle at constant speed. Describe how centripetal acceleration depends upon the objects speed and the radius of the circle. Recognize the direction of the force that causes centripetal acceleration. Explain how the rate of circular motion is changed by exerting torque on it.	5.7 (A-1)	

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VIII Universal Gravitation A. Motion in the Heavens and on Earth **(2 class sessions)**	Kepler's three laws of planetary motion state that planets move in elliptical orbits, that they sweep out equal areas in equal times, and that the square of the ratio of the periods of any two planets is equal to the cube of the ratio of their distances from the sun. Newton's law of universal gravitation states that the gravitational force between any two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers. The force is attractive and along a line connecting their centers.	Relate Kepler's laws of planetary motion to Newton's Law of universal gravitation. Calculate the periods and speeds of orbiting objects. Describe the method Cavendish used to measure *G* and the results to knowing *G*.	5.2 (B-1) (B-3) 5.4 (A-1) (A-3)	Text Lab: The Orbit Pocket Lab: Strange Orbit (8.1) Weight in a Free Fall (8.2) Water, Water, Everywhere (8.2) Lab Manual: Kepler's Laws 8-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Using the Law of Universal Gravitation. **(3 class sessions)**	A satellite in a circular orbit accelerates toward Earth at a rate equal to the acceleration of gravity at its orbital radius. Gravitational mass and inertial mass are two essentially different concepts. The gravitational and inertial masses of body, however, are numerically equal. Einstein's theory of gravity describes gravitational attraction as a property of space itself.	Solve problems involving orbital speed and period. Relate weightlessness to objects in free fall. Describe gravitational fields. Distinguish between inertial mass and gravitational mass. Contrast Newton's and Einstein's views about gravitation.	5.2 (B-1) (B-2) 5.3 (C-1) 5.4 (A-1) 5.7 (A-1) (A-3)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
IX Momentum and Its Conservation A. Impulse and Momentum **(1 class session)**	The momentum of an object is the product of its mass and velocity and is a vector quantity. The impulse given an object is the average net force exerted on the object multiplied by the time interval over the force acts. The impulse given an object is equal to the change in momentum of the object.	Compare the system before and after an event in momentum problems. Define the momentum of an object. Determine the impulse given to an object. Recognize that impulse equals the change in momentum of an object.	5.7 (A-1)	Text Lab: The Explosion Pocket Lab: Cart Momentum (9.1) Skateboard Fun (9.2) Lab Manual: Conservation of Momentum 9-1 Angular Momentum 9-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. The Conservation of Momentum **(4 class sessions)**	Newton's third law of motion explains momentum conservation in a collision because the forces that the colliding objects exert on each other are equal in magnitude and opposite in direction. The momentum is conserved in a closed, isolated system. Vector analysis is used to solve momentum-conservation problems in two dimensions.	Relate Newton's third law of motion to conservation of momentum in conditions and explosions. Recognize the conditions under which the momentum of a system is conserved. Apply conservation of momentum to explain the propulsion of rockets. Solve conservation of momentum problems in two dimensions by using vector analysis.	5.3 (C-1) 5.7 (A-2)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
X. Energy, Work and Simple Machines A. Energy and Work **(2 class sessions)**	Work is the transfer of energy by means of forces. The work done on the system is equal to the change in energy of the system. Work is the product of the force exerted on an object and the distance the object moves in the direction of the force. The area under the force-displacement graph is work. Power is the rate of doing work.	Describe the relationship between work and energy. Display an ability to calculate work done by a force. Identify the force that does work. Differentiate between work and power and correctly calculate power used.	5.1	Text Lab: Your Power Pocket Lab: Working Out (10.1) An Inclined Mass (10.2) Wheel and Axle (10,2) Lab Manual: Pulleys 10-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Machines **(2 class sessions)**	Machines, whether powered by engines or humans, do not change work, but make it easier. A machine eases the load either by changing the magnitude or the direction of the force exerted to do work. The mechanical advantage, *MA*, is the ratio of resistance force to effort force. The ideal mechanical advantage, *IMA*, is the ratio of the distances. In all real machines, *MA* is less than *IMA*.	Demonstrate knowledge of why simple machines are useful. Communicate an understanding of mechanical advantage in ideal and real machines. Analyze compound machines and describe them in terms of simple machines. Calculate efficiencies for simple and compound machines.	5.1 (A-4) 5.3 (C-1) 5.7 (B-3)	

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XI. Energy A. The Many Forms of Energy **(3 class sessions)**	The kinetic energy of an object is proportional to its mass and the square of its velocity. The gravitational potential energy of an object depends on the object's weight and its distance from Earth's surface. The sum of kinetic and potential energy is called mechanical energy. Elastic potential energy may be stored in an object as a result of its change in shape.	Use a model to relate work and energy. Calculate the kinetic energy of a moving object. Determine how to find the gravitational potential energy of a system.	5.7 (A-3) (A-6)	Text Lab: Down The Ramp Pocket Lab: Energy in Coins (11.1) Energy Exchange (11.2) Lab Manual: Conservation of Energy 11-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Conservation of Energy **(3 class sessions)**	The total energy of a closed isolated system is constant. Within the system, energy can change form, but the total amount of energy doesn't change. Momentum is conserved in collisions if the external force is zero.	Solve problems using the law of conservation of energy. Analyze collisions to find the change in kinetic energy.	5.1 (A-2) 5.4 (A-) 5.7 (A-6) (B-2) 5.2 (A-1)	

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XII. <u>Thermal</u> <u>Energy</u> A. Temperature and Thermal **(2 class sessions)**	Thermal energy is a measure of the internal motion of the particles. The Celsius and Kelvin temperature scales are used in scientific work. At absolute zero, no more thermal energy can be removed from a substance. Heat is energy transferred because of a difference in temperature. Specific heat is the quantity of heat required to raise the temperature of one kilogram of a substance by one Kelvin. In a closed, isolated system, heat may flow and change the thermal energy of parts of the system is constant	Describe the nature of thermal energy. Define temperature and distinguish it from thermal energy. Use the Celsius and Kelvin temperature scales and convert one to the other. Define specific heat and calculate heat transfer.	5.2 (B-3) 5.5 (B-1) 5.7 (B-1)	<u>Text Lab:</u> Heating Up <u>Pocket Lab:</u> Melting (12.1) Cool Times (12.2) Drip, Drip, Drip (12.2) <u>Lab Manual:</u> Specific Heat 12-1 Graphing The Efficiency of Solar Collectors 12-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Change of State and Laws of Thermodynamics **(3 class sessions)**	The heat of fusion is the quantity of heat needed to change one kilogram of a substance from its solid to liquid state at its melting point. The heat of vaporization is the quantity of heat needed to change one kilogram of a substance from its liquid to gaseous state at its boiling point. The total increase in energy of a system is the sum of the heat added to it and the work done on it. A heat engine continuously converts thermal energy to mechanical energy The entropy of the universe always increases, even if the entropy of a system may decrease because of some.	Define heats of fusion and vaporization. State the first and second laws of thermodynamics. Define heat engine, refrigerator, and heat pump. Define entropy.	5.1 (B-1) 5.6 (B-2) 5.7 (B-1) (B-2) (B-3)	

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XIV Waves and Energy Transfer A. Wave Properties **(2 class sessions)**	Waves transfer energy without transferring matter Mechanical waves require a medium. A continuous wave is a regularly repeating sequence of wave pulses. In transverse waves, the displacement of the medium is perpendicular to the direction of wave motion. In longitudinal waves, the displacement is parallel to the wave direction. In surface waves, matter is displaced in both directions. The wave source determines the frequency of the wave, *f*, which is the number of vibrations per second.	Identify how waves transfer energy without transferring matter. Contrast transverse and longitudinal waves. Relate wave speed, wavelength, and frequency.	5.1 (A-1) (A-4) 5.2 (A-1)	Text Lab: Coiled Spring Pocket Lab: Wave Reflections (14.2) Wave Interaction (14.2) Bent out of Shape (14.2) Lab Manual: Ripple Tank Waves 14-1 Velocity, Wavelength & Frequency in Ripple Tanks 14-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	The wavelength of a wave, λ, is the shortest distance between points where the wave pattern repeats itself. The medium determines wave speed, which can be calculated for continuous waves using the equation $v = \lambda f$.			

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B. Wave Behavior **(3 class sessions)**	When a wave crosses a boundary between two media, it is partially transmitted and partially reflected, depending on how much the wave velocities in the two media differ. When a wave moves to a medium where it has a higher wave speed, the reflected wave is erect. When moving to a medium where it has a lower wave speed, the reflected wave is inverted. The principle of superposition states that the displacement of a medium resulting from two or more waves is the algebraic sum of the displacements of the individual waves. Interference occurs when two or more waves move through a medium at the same time.	Relate a wave's speed to the medium in which the wave travels. Describe how waves are reflected and refracted at boundaries between media, and explain how waves diffract. Apply the principle of superposition to the phenomenon of interference.	5.1	

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	Destructive interference results in decreased wave displacement with its least amplitude at the node. Constructive interference results in increased wave displacement with its greatest amplitude at the antinode. A standing wave has stationary nodes and antinodes. When two-dimensional waves are reflected from boundaries, the angles of incidence and reflection are equal. The change in direction of waves at the boundary between two different media is called refraction. The spreading of waves around a barrier is called diffraction.			

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XV Sound A. Properties of Sound **(2 class sessions)**	Sound is a pressure variation transmitted through matter as a longitudinal wave. Sound waves have frequency, wave-length, and speed. Sound waves reflect and interfere. The amplitude of a sound wave is measured in decibels (dB). The loudness of sound as perceived by the ear and brain depends mainly on its amplitude. The frequency of a sound wave is heard as its pitch. The Doppler shift is the change in frequency of sound caused by the motion of either the source or detector.	Demonstrate knowledge of the nature of sound waves and the properties sound shares with other waves. Solve problems relating the frequency, wavelength, and velocity of sound. Relate the physical properties of sound waves to the way we perceive sound. Define the Doppler shift and identify some of its applications.	5.1 (A-2) 5.2 (A-1) 5.7 (B-1)	Text Lab: Speed of Sound Pocket Lab: Sound Off (15.2) Ring, Ring (15.2) Lab Manual: Sound Level of a Portable Radio or Tape Player 15-1 Resonance in an Open Tube 15-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. The Physics of Music **(2 class sessions)**	Sound is produced by vibrating objects in matter. Most sounds are complex waves that are composed of more than one frequency. An air column can resonate with a sound source, increasing its amplitude. Sound detectors convert the energy carried by a sound wave into another form of energy. The frequencies and intensities of the complex waves produced by a musical instrument determine the timbre that characteristic of that instrument. The fundamental frequency and harmonics can be described in terms of resonance.	Describe the origin of sound. Demonstrate an understanding of resonance, especially as applied to air columns. Explain in why there is a variation among instruments and among voices using the terms *timbre, resonance, fundamental,* and *harmonic.* Determine why beats occur.	5.3(C-1)	

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XVI Light A. Light Fundamentals **(2 class sessions)**	Light is an electromagnetic wave that stimulates the retina of the eye. Its wavelengths are between 400 and 700 nm. Light travels in a straight line through any uniform medium. In a vacuum, light has a speed of 3.00×10^8 m/s. The luminous flux of a light source is the rate at which light is emitted. It is measured in lumens**.** Illuminance is the rate at which light falls on a unit area. It is measured in lux.	Recognize that light is the visible portion of an entire range of electromagnetic frequencies. Describe the ray model of light. Solve problems involving the speed of light. Define *luminous intensity*, *luminous flux,* and *illuminance.* Solve illumination problems.	5.2 (B-3) (B-4)	Text Lab: Light Ray Paths Pocket Lab: An Illuminating Matter (16.1) Hot and Cool Colors (16.2) Soap Solutions (16.2) Light Polarization (16.2) Lab Manual: Polarized Light 16-1 Intense Light 16-2

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B. Light and Matter **(2 class sessions)**	Materials may be characterized as being transparent, translucent, or opaque, depending on the amount of light they reflect, transmit, or absorb. White light is a combination of the spectrum of colors, each having different wavelengths. White light can be formed by adding together the primary light colors: red, blue, and green. Polarized light consists of waves vibrating in a particular plane.	Explain the formation of color by light and by pigments or dyes. Explain the cause and give examples of interference in thin film. Describe methods of producing polarized light.	5.2	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XVII Reflection and refraction A. How Light Behaves at a Boundary **(3 class sessions)**	The Law of reflection states that the angle of reflection is equal to the angle of incidence. Refraction is the bending of light rays at the boundary between two media. Refraction occurs only when the incident ray strikes the boundary at an angle. Snell's law states $n_i \sin \theta_I = n_i \sin \theta_r$	Explain the law of reflection. Distinguish between diffuse and regular reflection and provide examples. Calculate the index of refraction in a medium.	5.7(B-1)	Text Lab: Bending of Light Pocket Lab: Reflections (17.1) Refraction (17.1) Cool Images (17.2) Personal Rainbow (17.2) Lab Manual: Reflection of Light 17-1 Snell's Law 17-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Applications of Reflected and Refracted Light. **(2 class sessions)**	Total internal reflection occurs when light is incident on a boundary from the medium with the larger index of refraction. If the angle of incidence is greater than the critical angle, no light leaves; it is all reflected. Light waves of different wavelengths have slightly different wavelengths have slightly different refractive indices. Thus, they are refracted at different angles. Light falling on a prism is dispersed into a spectrum of colors.	Explain total internal reflection. Define the critical angle. Explain effects caused by the refraction of light in a medium with varying refractive indices. Explain dispersion of light in terms of the index of refraction.	5.2 (B-3)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XVIII Mirrors and Lenses A. Mirrors **(2 class sessions)**	An Object is a source of diverging light rays. Some mirrors reflect light rays that appear to diverge from a point on the other side of a mirror. The point from which they appear is called virtual image. The image in a plane mirror is the same size as the object. The focal point of a convex or concave mirror is halfway between the center of curvature of the mirror and the mirror. Parallel light rays that are far from the principal axis are not reflected by spherical mirrors to converge at the focal point. This defect is called spherical aberration.	Explain how concave, convex, and plane mirrors form images. Locate images using ray diagrams, and calculate image location and size using equations. Explain the cause of spherical aberration and how the effect may be overcome. Describe uses of parabolic mirrors.	5.1 (B-1)	Text Lab: Seeing Is Believing Pocket Lab: Where is The Image? (18.1) Real or Virtual (18.1) Focal Points (18.1) Makeup (18.1) Burned Up (18.1) Fish-Eye Lens (18.2) Bright Ideas (18.2) Lab Manual Concave and Convex Mirrors 18-1 Concave and Convex Lenses 18-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Lenses **(3 class sessions)**	Convex lenses are thinner at their outer edges than at their centers. Concave lenses are thicker at their outer edges than at their centers. Convex lenses produce real, inverted images if the object is farther from the lens than the focal point. Concave lenses produce virtual, upright, reduced images. Lenses have spherical aberrations because parallel rays striking a lens near its edge do not focus at one spot. Lenses also focus light of different wavelength (color) at different locations. This is called chromatic aberration.	Describe how real and virtual images are formed by convex and concave lenses. Locate the image with a ray diagram and find the image location and size using a mathematical model. Define chromatic aberration and explain how it can be reduced. Explain how optical instruments such as microscopes and telescopes work.	5.2 (B-2) 5.3 (C-1)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XIX Diffraction and Interference of Light A. When Light Waves Interfere **(2 class sessions)**	Light has wave properties. Light passing through two closely spaced, narrow slits produces a pattern of dark, and light bands on a screen called an interference pattern Interference patterns can be used to measure the wavelength of light. Light passing through a narrow hole or slits is diffracted, or spread from a straight-line path, and produces a diffraction pattern on a screen. Both interference and diffraction patterns depend on the wavelength of light, the width or separation of the slits, and the distance to the screen.	Relate the diffraction of light to its wave characteristics. Explain how light falling on two closely spaced slits produces an interference pattern, and use measurements to calculate wavelengths of light. Apply geometrical models to explain single-slit diffraction and two-slit interference patterns.	5.1 (A-3) (B-1)	Text Lab: Wavelengths of Colors Pocket Lab: Hot Lights (19.1) Laser Spots (19.1) Lights in the Night (19.2) Lab Manual: Double-Slit Interference 19-1 White Light Holograms 19-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Applications of Diffraction **(1 class session)**	Diffraction gratings consist of large numbers of slits and produce narrow interference patterns. Diffraction gratings can be used to measure the wavelength of light precisely or to separate light composed of different wavelengths. Diffraction limits the ability of a lens to distinguish two closely space objects.	Explain how diffraction gratings form interference patterns and how they are used in grating spectrometers. Discuss how diffraction limits the ability of a lens to distinguish two closely spaced objects.	5.2 (B-3)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XX <u>Static Electricity</u> A. Electrical Charge **(2 class sessions)**	There are two kinds of electrical charge, positive and negative. Like charges repel; unlike charges attract. Electrical charge is not created or destroyed; it is conserved. Objects can be charged by the transfer of electrons. Charges added to one part of an insulator remain on that part. Charges added to a conductor quickly spread over the surface of the object.	Recognized that objects are charged exert forces, both attractive and repulsive. Demonstrate that charging is the separation, not the creation, of electrical charges. Describe the differences between conductors and insulators.	5.7 (A-4)	<u>Text Lab:</u> What's The Charge? <u>Pocket Lab:</u> Charge UP (20.2) Reach OUT (20.2) <u>Lab Manual:</u> Investigating Static Electricity 20-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Electrical Force **(3 class sessions)**	When an electroscope is charged, electrical forces cause its thin metal leaves to spread. An object can be charged by conduction by touching a charged object to it. Coulomb's law states that the force between two charges varies directly with the product of their charge and inversely with the square of the distance between them. The SI unit of charge is the coulomb.	Summarize the relationship between forces and charges. Describe how an electroscope detects electric charge. Explain how to charge by conduction and induction. Use Coulomb's law to solve problems relating to electrical force. Develop a model of how charged objects can attract a neutral object.	5.2 (B-1) 5.7 (A-4)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXI Electric Fields A. Creating and Measuring Electric Fields **(2 class sessions)**	An electric field exists around any charge object. The field produces forces on other charged bodies. The electric field intensity is the force per unit charge. The direction of the electric field is the direction of the force on a tiny, positive test charge. Electric field lines provide a picture of the electric field. They are directed away from positive charges and toward negative charges.	Define and measure an electric field. Solve problems relating to charge, electric fields, and forces. Diagram electric field lines.	5.7 (A-4)	Text Lab: Charges, Energy, and Voltage Pocket Lab: Electric Fields (21.1) Lab Manual: The Capacitor 21-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Application of Electric Fields **(2 class sessions)**	Electric potential difference is the charge in potential energy per unit charge in an electric field. Electric potential differences are measured in volts. The electric field between two parallel plates is uniform between the plates except near the edges. Robert Millikan's experiments showed that electric charge is quntized and that the negative charge carried by an electron is 1.60×10^{-19} C. Charges will move in conductors until the electric potential is the same everywhere on the conductor.	Define and calculate electric potential difference. Explain how Millikan used electric fields to find the charge of the electron. Determine where charges reside on solid and hollow conductors. Describe capacitance and solve capacitor problems.	5.7 (A-4)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	A charged object can have its excess charge removed by touching it to Earth or to an object touching Earth. This is called grounding. Electric fields are strongest near sharply pointed conductors. Capacitance is the ratio of the charge on a body to its electric potential difference. It is independent of the charge on the body and the electric potential difference across it.			

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXII Current Electricity A. Current and Circuits **(3 class sessions)**	Batteries, generators, and solar cells convert various forms of energy to electric energy. In an electric circuit, electric energy is transmitted from a device that produces electric energy to a resistor or other device that converts electric energy into the form needed. As a charge moves through resistors in a circuit, its potential energy is reduced. The energy released when the charge moves around the remainder of the circuit equals the work done to give the charge its initial potential energy. One ampere is one coulomb per second.	Define an electric current and the ampere. Describe conditions that create current in an electric circuit. Draw circuits and recognize they are closed loops. Define power in electric circuits. Define resistance and describe Ohm's law.	5.1 (B-1) 5.7 (B-1) (B-3)	Text Lab: Mystery Cans Pocket Lab: Lightning Up (22.1) Running Out (22.1) Appliances (22.2) Heating Up (22.2) Lab Manual: OHM'S Law 22-1 Electrical Equivalent of Heat 22-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	Electric power is found by multiplying voltage by current. The resistance of a device is the ratio of the voltage across it divided by the current through it. In a device that obeys Ohm's law, the resistance remains constant as the voltage and current change. The current in a circuit can be varied by changing either the voltage or the resistance, or both. In a circuit diagram, conventional current is used. This is the direction in which a positive charge would move.			

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Using Electric Energy **(2 class sessions)**	The thermal energy produced in a circuit from electric energy is equal to $I^2 Rt$. A kilowatt-hour, kWh, is an energy unit. It is equal to 3.6 x 10^6 J.	Explain how electric energy is converted into thermal energy. Determine why high-voltage transmission lines are used to carry electric energy over long distances. **Define *kilowatt-hour*.**	5.7(B-1) (B-3)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXIII Series and Parallel Circuits A. Simple Circuits **(3 class sessions)**	The current is the same everywhere in a simple series circuit. The equivalent resistance of a series circuit is the sum of the resistances of its parts. The sum of the voltage drops across resistors in series is equal to the potential difference applied across the combination. A voltage divider is a series circuit used to produce a voltage source from a higher-voltage battery. The voltage drops across all branches of a parallel circuit are the same. In a parallel circuit, the total current is equal to the sum of the currents in the branches.	Describe both a series connection and a parallel connection and state the important characteristics of each. Calculate current, voltage drops, and equivalent resistance for devices connected in series and parallel. Describe a voltage divider and solve problems involving one.	5.1	Text Lab: Circuits Pocket Lab: Series Resistance (23.1) Parallel Resistance (23.1) Ammeter Resistance (23.2) Lab Manual: Series Resistance 23-1 Parallel Resistance 23-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Application of Circuits. **(3 class sessions)**	A fuse of a circuit breaker, placed in series with appliances, creates an open circuit when dangerously high current flow. A complex circuit is often a combination of series and parallel branches. An ammeter is used to measure the current in a branch or part of a circuit. An ammeter always has a low resistance and is connected in series. A voltmeter measures the potential difference (voltage) across any part or combination of parts of a circuit. A voltmeter always has a high resistance and is connected in parallel with the part of the circuit being measured.	Explain how fuses, circuit breakers, and ground-fault interrupters protect household wiring. Analyze combined series-parallel circuits and calculate the equivalent resistance of such circuits. State the importance characteristics of voltmeters and ammeters, and explain how each is used in circuits.	5.1 (B-1) (C-1) 5.4 (C-1)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXIV Magnetic Fields A. Magnets: Permanent and Temporary **(3 class sessions)**	Like magnetic poles repel; unlike magnetic poles attract. Magnetic fields exit from the north pole of a magnet and enter its south pole. A magnetic field exists around any wire that carries current. A coil of wire that carries a current has a magnetic field. The field about the coil is like the field about a permanent magnet.	Describe the properties of magnets and the origin of magnetism in materials. Compare various magnetic fields.	5.1 (A-4) 5.2 (B-1) 5.6 (A-7)	Text Lab: Coils and Currents Pocket Lab: Monopoles? (24.1) Funny Balls (24.1) 3-D Magnetic Fields (24.1) Lab Manual: Nature of Magnetism 24-1 Principles of Electromagnetism 24-2 Variation in the Strength of Electromagnets 24-3

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Forces Caused by Magnetic Fields **(3 class sessions)**	When a current-carrying wire is placed in a magnetic field, there exists a force on the wire that is perpendicular to both the field and the wire. Galvanometers are based on this principle. The strength of a magnetic field is measured in teslas (one Newton per ampere per meter) An electric motor consist of a coil of wire places in a magnetic field, when there is a current in the coil, the coil rotates as a result of the force on the wire in the magnetic field. The force a magnetic field exerts on a charged particle depends on the velocity and charge of the particle and the strength of the field.	Relate magnetic induction to the direction of the force on a current-carrying wire in a magnetic field. Solve problems involving magnetic field strength and the forces on current-carrying wires, and on moving, charges particles in magnetic fields. Describe the design and operation of an electric motor.	5.7 (A-7)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	The direction of the force is perpendicular to both the field and the particle's velocity.			

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXV Electromagnetic Induction A. Creating Electric Current From Changing Magnetic Fields **(3 class sessions)**	Michael Faraday discovered that if a wire moves through a magnetic field, an electric current can flow. The current produced depends upon the angle between the velocity of the wire and the magnetic field. Electromotive force, *EMF*, is the potential difference created across the moving wire. *EMF* is measured in volts. The *EMF* in a straight length of wire moving through a uniform magnetic field is the product of the magnetic field, *B*, the length of the wire, *L*, and the component of the velocity of the moving wire *v*, perpendicular to the field.	Explain how a changing magnetic field produces an electric current. Define electromotive force, and solve problems involving wires moving in a magnetic field. Describe how an electric generator works and how it differs from a motor. Recognize the difference between peak and effective voltage and current.	5.1 (A-1) (A-2) (C-1) 5.2 (A-1) (B-3) 5.7 (A-6) (A-7) (A-8)	Text Lab: Swinging Coils Pocket Lab: Making Currents (25.1) Motor and Generator (25.1) Slow Motor (25.2) Slow Magnet (25.2) Lab Manual: Electromagnetic Induction 1 25-1 Electromagnetic Induction 2 25-2

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
	A generator and a motor are similar devices. A generator converts mechanical energy to electrical energy; a motor converts electrical energy to mechanical energy.			

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Changing Magnetic Fields Induce *EMF* **(2 class sessions)**	Lenz's law states that an induced current is always produced in a direction such that the magnetic field resulting from the induced current opposes the change in the magnetic field that is causing the induced current. Self-inductance is a property of a wire carrying a changing current. The faster the current is changing, the greater the induced *EMF* that opposes that change. A transformer has two coils wound about the same core. An AC current through the primary coil induces an alternating *EMF* in the secondary coil. The voltages in alternating-current circuits may be increased or decreased by transformers.	State Lenz's law, and explain back-*EMF* and how it affects the operation of motors and generators. Explain self-inductance and how it affects circuits. Describe a transformer and solve problems involving voltage, current, and turns ratios.	5.7 (A-7) (A-8) 5.7 (B-2)	

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
XXVI Electromagnetism A. Interaction Between Electric and Magnetic Fields and Matter **(3 class sessions)**	The ratio of charge to mass of the electron was measured by J.J. Thompson using balanced electric and magnetic fields in a cathode-ray tube. An electron's mass can be found by combining Thompson's result with Millikan's measurement of the electron's charge. The mass spectrometer uses both electric and magnetic fields to measure the masses of ionized atoms and molecules.	Describe the measurement of the charge-to-mass ratio of the electron and solve problems related to this measurement. Explain how a masses spectrometer separates ions of different masses and solve problems involving this instrument.	5.1	Text Lab: Simulating a Mass Spectrometer Pocket Lab: Rolling Along (26.1) Catching The Wave (26.2) More Radio Stuff (26.2) Lab Manual: Mass of an Electron 26-1

OUTLINE	CONCEPTS	SKILLS	N.J. C.C.C. STANDARDS	SUGGESTED ACTIVITIES
B. Electric and Magnetic Fields in Space **(1 class session)**	Electromagnetic waves are coupled, changing electric and magnetic fields that move through space. Changing currents in an antenna generate electromagnetic waves. The frequency of oscillating currents can be selected by a resonating coil and capacitor circuit. Microwave and infrared waves can accelerate electrons in molecules, producing thermal energy. When high-energy electrons strike an anode in an evacuated tube, their kinetic energies are converted to electromagnetic waves of very high energy called X rays.	Describe how electric and magnetic fields can produced more electric and magnetic fields. Explain how accelerated charges produce electromagnetic waves. Explain the process by which electromagnetic waves are detected.	5.1 (A-4) 5.2 (B-3) 5.8 (A-8) (B-4)	