

**Virginia Science Grades 9-12  
Curriculum Standards**

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<b>PHYSICS</b>	<b>Boardworks High School Physics Presentation</b>
<b>Standard PH.5</b>	
<b>The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes. Key concepts include:</b>	
<b>a) Linear motion;</b>	
i) Velocity is the change in distance divided by the change in time.	Speed and Velocity Displacement, Velocity and Acceleration
ii) A straight-line, position-time graph indicates constant velocity.	Displacement, Velocity and Acceleration
iii) A straight-line, position-time graph indicates constant acceleration.	Displacement, Velocity and Acceleration
iv) A horizontal-line, velocity-time graph indicates zero acceleration.	Displacement, Velocity and Acceleration
v) The slope of a distance-time graph is the velocity.	Displacement, Velocity and Acceleration
vi) The slope of a velocity-time graph is the acceleration.	Displacement, Velocity and Acceleration
vii) Acceleration is the change in velocity divided by the change in time.	Acceleration Displacement, Velocity and Acceleration
viii) Construct and analyze displacement (d) vs. time (t), velocity (v) vs. time (t), and acceleration (a) vs. time (t) graphs.	Acceleration Displacement, Velocity and Acceleration Speed and Velocity
ix) Solve problems involving displacement, velocity, acceleration, and time in one and two dimensions (only constant acceleration)	Acceleration Displacement, Velocity and Acceleration Speed and Velocity
x) Resolve vector diagrams involving distance and velocity.	Vectors and Scalars
<b>b) Uniform circular motion;</b>	
i) Distinguish between centripetal and centrifugal force.	Circular Motion
<b>c) Projectile motion.</b>	
i) Draw vector diagrams of a projectile's motion. Find range, trajectory, height of the projectile, and time of flight (uniform field, no air resistance).	Projectiles
<b>d) Newton's laws of motion;</b>	
i) An object with no force acting on it moves with constant velocity.	Newton's First Law
ii) The acceleration of a body is directly proportional to the net force on it and inversely proportional to its mass.	Newton's Third Law
iii) When one object exerts a force on a second object, the second exerts a force on the first that is equal in magnitude but opposite in direction.	Newton's Third Law

iv) Qualitatively explain motion in terms of Newton's Laws.	Newton's First Law Newton's Second Law Newton's Third Law
v) Solve problems involving force (F), mass (m), and acceleration (a).	Newton's Second Law
<b>e) Gravitation;</b>	
i) Weight is the gravitational force acting on a body.	Gravity Mass and Weight
ii) Friction is a force that acts in a direction opposite the velocity.	Friction
iii) <i>For small angles of oscillation, a pendulum exhibits simple harmonic motion.</i>	–
iv) <i>Newton's Law of Universal Gravitation can be used to determine the force between objects separated by a known distance, and the distance between objects with a known gravitational attraction.</i>	–
v) Solve problems related to free-falling objects, including 2-D motion.	Projectiles
vi) <i>Solve problems using Newton's Law of Universal Gravitation</i>	–
vii) <i>Solve problems using the coefficient of friction.</i>	–
viii) Solve problems involving multiple forces, using free-body diagrams.	Free-Body Diagrams
<b>f) Planetary motion</b>	Gravity
<b>g) Work, power, and energy.</b>	
i) Work is the product of the force exerted on an object and the distance the object moves in the direction of the force.	Work
ii) Power is the rate of doing work.	Power
iii) Work and energy are measured in Joules, which is a derived unit equal to a Nm or kgm <sup>2</sup> /s <sup>2</sup> .	Work
iv) Power is measured in Watts, which is a derived unit equal to a J/s.	Electrical Power
v) <i>Solve problems involving work, power, and energy.</i>	–
<b>Standard PH.6</b> <b>The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include:</b>	
<b>a) Kinetic and potential energy;</b>	
i) Calculate potential and kinetic energy from theoretical and experimental situations.	Gravitational and Potential Energy Kinetic Energy
<b>b) Elastic and inelastic collisions.</b>	
i) <i>Model conservation of energy and momentum, using elastic and inelastic collisions.</i>	–
<b>c) Electric power</b>	
i) Electric power (watt) is change in electrical energy divided by corresponding change in time.	Electrical Power
ii) Current (ampere) is the amount of charge that moves through a circuit element divided by the elapsed time.	Current and Potential Difference

iii) Electric potential difference (voltage) is change in electric potential energy per unit charge.	Current and Potential Difference
iv) <i>In any system of electrical charge, electrical movement, or electrical interaction, both charge and energy are conserved.</i>	–
<b>Standard PH.7</b>	
<b>The student will investigate and understand properties of fluids. Key concepts include:</b>	
<b>a) Density and pressure;</b>	
<i>i) Determine if a given object will float or sink in water, given its mass and volume or dimensions.</i>	–
<b>Standard PH.8</b>	
<b>The student will investigate and understand that energy can be transferred and transformed to provide usable work. Key concepts include:</b>	
<b>a) Transformation of energy among forms including mechanical, thermal, electrical, gravitational, chemical, and nuclear;</b>	
i) Illustrate that energy can be transformed from one form to another, using examples from everyday life and technology.	Energy Transfers
ii) Qualitatively identify the various forms of energy transformations in simple demonstrations.	Energy Transfers Fossil Fuels
<b>b) Efficiency of systems.</b>	
i) Calculate efficiency by identifying the useful energy in a process.	Energy Transfers
<b>Standard PH.9</b>	
<b>The student will investigate and understand how to use models of transverse and longitudinal waves to interpret wave phenomena. Key concepts include:</b>	
<b>a) Wave characteristics (period, wavelength, frequency, amplitude, and phase).</b>	
i) Period, wavelength, and frequency are measured in seconds, meters, and Hertz.	Transverse Waves
ii) Identify examples of longitudinal and transverse waves.	Waves
iii) Differentiate between transverse and longitudinal waves, using simple models (slinky, stadium waves).	Longitudinal Waves Transverse Waves Waves
iv) Illustrate period, wavelength, and amplitude on a graphic representation of a harmonic wave.	Longitudinal Waves
v) Solve problems involving frequency, period, wavelength, and velocity.	Longitudinal Waves Transverse Waves
vi) Distinguish between waves that are in-phase and those that are out-of-phase.	Superposition and Interference
<b>b) Fundamental wave processes (reflection, refraction, diffraction, interference, polarization, Doppler effect);</b>	
i) Reflection is the change of direction of the wave in the original medium.	Reflection
ii) Refraction is the change of direction (bending) of the wave in the new medium.	Refraction
iii) Diffraction is the spreading of a wave around a barrier or an aperture.	Diffraction

iv) Graphically illustrate reflection and refraction of a wave when it encounters a change in medium or a boundary.	Refraction Reflection
v) Graphically illustrate constructive and destructive interference.	Interference Superposition and Interference
vi) <i>Identify a standing wave, using a string.</i>	–
<b>c) Light and sound in terms of wave models.</b>	
i) The pitch of a note is determined by the frequency of the sound wave.	Sound
ii) <i>The color of light is determined by the frequency of the light wave.</i>	–
iii) As the amplitude of a sound wave increases, the loudness of the sound increases.	Sound
iv) <i>As the amplitude of a light wave increases, the brightness of the light increases.</i>	–
<b>Standard PH.10</b> <b>The student will investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation. Key concepts include:</b>	
<b>a) The properties and behaviors of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays;</b>	
i) The long wavelength, low frequency portion of the electromagnetic spectrum is used for communication (e.g., radio, TV, cellular phone).	Electromagnetic Waves
ii) Medium wavelengths (infrared) are used for heating and night-vision-enhancing devices.	Electromagnetic Waves
iii) Visible light comprises a very narrow portion of the electromagnetic spectrum.	Electromagnetic Waves
iv) Ultraviolet wavelengths (shorter than the visible spectrum) are responsible for sunburn.	Electromagnetic Waves
v) X-rays and gamma rays are the highest frequency and shortest wavelength and are used primarily for medical purposes.	Electromagnetic Waves Gamma X-rays
<b>b) Current applications based on the wave properties of each band.</b>	–
<b>Standard PH.11</b> <b>The student will investigate and understand, in describing optical systems, how light behaves in the fundamental processes of reflection, refraction, and image formation. Key concepts include:</b>	
<b>a) Application of the laws of reflection and refraction;</b>	
i) For a converging lens, the focal point is the point at which a beam of light parallel to the principal axis converges.	Lenses
ii) For a diverging lens, the focal point is the point from which a beam of light parallel to the principal axis appears to originate.	Lenses
iii) <i>A real image is formed by converging lights rays and can be displayed on a screen.</i>	–

iv) A virtual image can be seen by an observer but cannot be projected on a screen because the light does not actually emanate from the image.	–
v) The focal point is the point at which rays converge or from which they appear to diverge in a lens or mirror.	Lenses
vi) The index of refraction is the ratio of the speed of light in a vacuum to the speed of light in the medium.	Refractive Index
vii) Investigate propagation, refraction, and reflection, using the ray model of light.	Reflection Refraction
<b>b) Construction and interpretation of ray diagrams.</b>	
i) Construct ray diagrams to verify the laws of reflection and refraction.	Reflection Refraction
<b>c) Development and use of mirror and lens equations</b>	
i) Solve problems dealing with object and image distance, object and image size, and focal length, using the lens and mirror equations.	–
<b>d) Predictions of types, size, and position of real and virtual images.</b>	
i) Illustrate characteristics of real and virtual images, using examples (lens and mirror).	–
ii) Identify the type (real and virtual) and size of image formed by concave lenses and by convex lenses when the object is located at various locations including inside the focal point, at the focal point, at twice the focal point, and beyond twice the focal point.	Lenses
<b>Standard PH.12</b> <b>The student will investigate and understand how to use the field concept to describe the effects of gravitational, electric, and magnetic forces. Key concepts include:</b>	
<b>a) Inverse square laws (Newton's law of universal gravitation and Coulomb's law);</b>	
i) Newton's Law of Universal Gravitation states that every particle in the universe attracts every other particle in the universe. $F = G (m_1 m_2) / r^2$ . ( $F$ is the force, $G$ is the universal gravitation constant, $m$ is the mass of the two particles, and $r$ is the distance between them.)	–
ii) Coulomb's law states that the magnitude $F$ of the electrostatic force exerted by one point charge on another point charge is directly proportional to the magnitudes of $q_1$ and $q_2$ of the charges and inversely proportional to the square of the distance $r$ between them: $F = k (q_1 q_2) / r^2$ .	–
<b>b) Operating principles of motors, generators, transformers, and cathode ray tubes.</b>	
i) The rotation of the coil of a motor or a generator through a magnetic field is used to transfer energy.	Motors
<b>Standard PH.13</b> <b>The student will investigate and understand how to diagram and construct basic electrical circuits and explain the function of various circuit components. Key concepts include:</b>	
<b>a) Ohm's law;</b>	
i) According to Ohm's law, the resistance equals the voltage divided by the current.	Calculating Resistance

ii) Voltage difference is change in electrical potential energy per unit charge.	–
iii) Apply Ohm's law to a series and a parallel circuit.	Calculating Resistance Factors Affecting Resistance 1 Factors Affecting Resistance 2
iv) Solve simple circuits using Ohm's law.	Factors Affecting Resistance 2
<b>b) Series, parallel, and combined circuits;</b>	
i) Recognize a series and a parallel circuit.	Series and Parallel Circuits
<b>c) Circuit components including resistors, batteries, generators, fuses, switches, and capacitors.</b>	
i) Assemble simple circuits composed of batteries and resistors in series and in parallel.	Series and Parallel Circuits
<b>Standard PH.14</b> The student will investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied by Newtonian physics. Key concepts include:	
<b>a) Wave/particle duality;</b>	
i) Electrons rotating around the nucleus of an atom can be treated as standing waves in order to model the atomic spectrum	–
<b>b) Wave properties of matter;</b>	Wave Properties of Particles
<b>c) matter/energy equivalence; and</b>	
i) The dramatic examples of the mass-energy transformation are the fusion of hydrogen in the sun, which provides light and heat for the earth, and the fission process in nuclear reactors that provide electricity.	Nuclear Fission Nuclear Fusion
<b>d) Quantum mechanics and uncertainty.</b>	
i) Quantum mechanics requires an inverse relationship between the measurable location and the measurable momentum of a particle. The more accurately one determines the position of a particle, the less accurately the momentum can be known, and vice versa. This is known as the Heisenberg uncertainty principle.	–
<b>e) Relativity;</b>	
i) Objects cannot travel faster than the speed of light.	–
<b>f) Nuclear physics;</b>	
i) The nuclear force binds protons and neutrons in the nucleus.	–
ii) Fission is the breakup of heavier nuclei to lighter nuclei.	Nuclear Fission
iii) Fusion is the combination of lighter nuclei to heavier nuclei.	Nuclear Fusion
<b>g) Solid state physics;</b>	
i) Many substances in the natural world have a crystal structure, including most metals and minerals.	–
<b>h) Superconductivity;</b>	–

<b>i) Radioactivity.</b>	
i) Alpha, beta, and gamma are different emissions associated with radioactive decay.	Radioactivity Types of Radioactivity