PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 1: INTRODUCTION TO PHYSICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: What is Physics?		These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment B: Scientific Notation and Unit Conversions	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment C: Significant Figures	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment D: Vectors and Scalars	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment E: Graphical Resolution of Vectors	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment F: Mathematical Resolution of Vectors	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.
Segment G: Graphing Relationships	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physics.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.	These foundational concepts are not explicitly stated in the GSEs but are essential for understanding main ideas and engaging in problem solving in physical science.

PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 2: DESCRIBING MOTION

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: Distance and Displacement	SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time. a. Plan and carry out an investigation of one-dimensional motion to calculate average and instantaneous speed and velocity. • Analyze one-dimensional problems involving changes of direction, using algebraic signs to represent vector direction. • Apply one-dimensional kinematic equations to situations with no acceleration, and positive, or negative constant acceleration. b. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time. c. Ask questions to compare and contrast scalar and vector quantities.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. a. Plan and carry out an investigation to analyze the motion of an object using mathematical and graphical models. (Clarification statement: Mathematical and graphical models could include distance, displacement, speed, velocity, time and acceleration.)	
Segment B: Speed and Velocity			
Segment C: Acceleration and Kinematic Equations			

PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 2: DESCRIBING MOTION

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment D: Graphing Motion	SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time. b. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. a. Plan and carry out an investigation to analyze the motion of an object using mathematical and graphical models. (Clarification statement: Mathematical and graphical models could include distance, displacement, speed, velocity, time and acceleration.)	S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects. a. Analyze and interpret data to identify patterns in the relationships between speed and distance, and velocity and acceleration. (Clarification statement: Students should be able to analyze motion graphs, but students should not be expected to calculate velocity or acceleration.)
Segment E: Free Fall	SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time. a. Plan and carry out an investigation of one-dimensional motion to calculate average and instantaneous speed and velocity. • Analyze one-dimensional problems involving changes of direction, using algebraic signs to represent vector direction. • Apply one-dimensional kinematic equations to situations with no acceleration, and positive, or negative constant acceleration.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. a. Plan and carry out an investigation to analyze the motion of an object using mathematical and graphical models. (Clarification statement: Mathematical and graphical models could include distance, displacement, speed, velocity, time and acceleration.) c. Analyze and interpret data to identify the relationship between mass and gravitational force for falling objects.	

UNIT 2: DESCRIBING MOTION

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment F: Relative Velocity	SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time. a. Plan and carry out an investigation of one-dimensional motion to calculate average and instantaneous speed and velocity. • Analyze one-dimensional problems involving changes of direction, using algebraic signs to represent vector direction. • Apply one-dimensional kinematic equations to situations with no acceleration, and positive, or negative constant acceleration.		
Segment G: Horizontally Launched Projectiles	SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time. d. Analyze and interpret data of two-dimensional motion with constant acceleration. • Resolve position, velocity, or acceleration vectors into components (x and y, horizontal and vertical). • Add vectors graphically and mathematically by adding components. • Interpret problems to show that objects moving in two dimensions have independent motions along each coordinate axis. • Design an experiment to investigate the projectile motion of an object by collecting and analyzing data using kinematic equations. • Predict and describe how changes to initial conditions affect the resulting motion. • Calculate range and time in the air for a horizontally launched projectile.		

PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 3: FORCES

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: Newton's Laws Overview	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. a. Construct an explanation based on evidence using Newton's Laws of how forces affect the acceleration of a body. • Explain and predict the motion of a body in absence of a force and when forces are applied using Newton's 1st Law (principle of inertia). • Calculate the acceleration for an object using Newton's 2nd Law, including situations where multiple forces act together. • Identify the pair of equal and opposite forces between two interacting bodies and relate their magnitudes and directions using Newton's 3rd Law.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. b. Construct an explanation based on experimental evidence to support the claims presented in Newton's three laws of motion. (Clarification statement: Evidence could demonstrate relationships among force, mass, velocity, and acceleration.)	S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects. b. Construct an explanation using Newton's Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object. c. Construct an argument from evidence to support the claim that the amount of force needed to accelerate an object is proportional to its mass (inertia).
Segment B: Free Body Diagrams	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. b. Develop and use a model of a Free Body Diagram to represent the forces acting on an object (both equilibrium and non-equilibrium).	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. b. Construct an explanation based on experimental evidence to support the claims presented in Newton's three laws of motion. (Clarification statement: Evidence could demonstrate relationships among force, mass, velocity, and acceleration.)	

PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 3: FORCES

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment C: Newton's Second Law Part 1	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. a. Construct an explanation based on evidence using Newton's Laws of how forces affect the acceleration of a body. • Calculate the acceleration for an object using Newton's 2nd Law, including situations where multiple forces act together. b. Develop and use a model of a Free Body Diagram to represent the forces acting on an object (both equilibrium and non-equilibrium). c. Use mathematical representations to calculate magnitudes and vector components for typical forces including gravitational force, normal force, friction forces, tension forces, and spring forces.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. b. Construct an explanation based on experimental evidence to support the claims presented in Newton's three laws of motion. (Clarification statement: Evidence could demonstrate relationships among force, mass, velocity, and acceleration.)	S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects. b. Construct an explanation using Newton's Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object. c. Construct an argument from evidence to support the claim that the amount of force needed to accelerate an object is proportional to its mass (inertia).
Segment D: Newton's Second Law Part 2			

PHYSICS IN MOTION
gpb.org/physics-motion

Standards Alignment Crosswalk

UNIT 3: FORCES

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment E: Newton's Third Law	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. a. Construct an explanation based on evidence using Newton's Laws of how forces affect the acceleration of a body. • Identify the pair of equal and opposite forces between two interacting bodies and relate their magnitudes and directions using Newton's 3rd Law.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. b. Construct an explanation based on experimental evidence to support the claims presented in Newton's three laws of motion. (Clarification statement: Evidence could demonstrate relationships among force, mass, velocity, and acceleration.)	S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects. b. Construct an explanation using Newton's Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object. c. Construct an argument from evidence to support the claim that the amount of force needed to accelerate an object is proportional to its mass (inertia).
Segment F: Gravity	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. b. Develop and use a model of a Free Body Diagram to represent the forces acting on an object (both equilibrium and non-equilibrium). c. Use mathematical representations to calculate magnitudes and vector components for typical forces including gravitational force, normal force, friction forces, tension forces, and spring forces. e. Develop and use a model to describe the mathematical relationship between mass, distance, and force as expressed by Newton's Universal Law of Gravitation.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. b. Construct an explanation based on experimental evidence to support the claims presented in Newton's three laws of motion. (Clarification statement: Evidence could demonstrate relationships among force, mass, velocity, and acceleration.) c. Analyze and interpret data to identify the relationship between mass and gravitational force for falling objects.	S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature. a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact.

UNIT 3: FORCES

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment G: Circular Motion	SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects. b. Develop and use a model of a Free Body Diagram to represent the forces acting on an object (both equilibrium and non-equilibrium). c. Use mathematical representations to calculate magnitudes and vector components for typical forces including gravitational force, normal force, friction forces, tension forces, and spring forces. d. Plan and carry out an investigation to gather evidence to identify the force or force component responsible for causing an object to move along a circular path. • Calculate the magnitude of a centripetal acceleration.		

UNIT 4: MOMENTUM AND ENERGY

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: Momentum and Impulse	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. d. Construct an argument supported by evidence of the use of the principle of conservation of momentum to • explain how the brief application of a force creates an impulse. • describe and perform calculations involving one dimensional momentum.		
Segment B: Conservation of Momentum	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. a. Ask questions to compare and contrast open and closed systems. d. Construct an argument supported by evidence of the use of the principle of conservation of momentum to • describe and perform calculations involving one dimensional momentum. • connect the concepts of Newton's 3rd law and impulse.		

UNIT 4: MOMENTUM AND ENERGY

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment C: Collisions	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. d. Construct an argument supported by evidence of the use of the principle of conservation of momentum to • describe and perform calculations involving one dimensional momentum. • experimentally compare and contrast inelastic and elastic collisions.		
Segment D: Work	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. a. Ask questions to compare and contrast open and closed systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the amount of work performed by a force on an object.	SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion. d. Use mathematics and computational thinking to identify the relationships between work, mechanical advantage, and simple machines.	

UNIT 4: MOMENTUM AND ENERGY

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment E: Gravitational Potential Energy and Kinetic Energy	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the kinetic energy of an object.		S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system. a. Analyze and interpret data to create graphical displays that illustrate the relationships of kinetic energy to mass and speed, and potential energy to mass and height of an object. b. Plan and carry out an investigation to explain the transformation between kinetic and potential energy within a system (e.g., roller coasters, pendulums, rubber bands, etc.).
Segment F: Work-Energy Theorem	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. a. Ask questions to compare and contrast open and closed systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the kinetic energy of an object. • Calculate the amount of work performed by a force on an object.		

UNIT 4: MOMENTUM AND ENERGY

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment G: Spring Potential Energy	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the amount of work performed by a force on an object.		
Segment H: Conservation of Energy	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. a. Ask questions to compare and contrast open and closed systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the kinetic energy of an object. • Calculate the amount of work performed by a force on an object. c. Plan and carry out an investigation demonstrating conservation and rate of transfer of energy (power) to solve problems involving closed systems.		S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system. c. Construct an argument to support a claim about the type of energy transformations within a system [e.g., lighting a match (light to heat), turning on a light (electrical to light)].

UNIT 4: MOMENTUM AND ENERGY

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment I: Power	SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems. b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem. • Calculate the amount of work performed by a force on an object. c. Plan and carry out an investigation demonstrating conservation and rate of transfer of energy (power) to solve problems involving closed systems.		

UNIT 5: ELECTRICITY AND MAGNETISM

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: Introduction to Electricity	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. a. Develop and use mathematical models and generate diagrams to compare and contrast the electric and gravitational forces between two charged objects.		S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature. a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact.
Segment B: Static Electricity	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. b. Plan and carry out investigations to demonstrate and qualitatively explain charge transfer by conduction, friction, and induction.		S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature. a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact. b. Plan and carry out investigations to demonstrate the distribution of charge in conductors and insulators. (Clarification statement: Include conduction, induction, and friction.)
Segment C: Coulomb's Law	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. a. Develop and use mathematical models and generate diagrams to compare and contrast the electric and gravitational forces between two charged objects.		

UNIT 5: ELECTRICITY AND MAGNETISM

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment D: Electric Potential Energy and Electric Potential	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. c. Construct an explanation based on evidence of the behavior of charges in terms of electric potential energy.		
Segment E: Current Electricity Segment F: Ohm's Law	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. d. Plan and carry out an investigation of the relationship between voltage, current, and power for direct current circuits. (Clarification statement: Application of Ohm's Law to different circuit configurations, not limited to parallel and series, and calculations of equivalent resistance are expected).	SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism. a. Use mathematical and computational thinking to support a claim regarding relationships among voltage, current, and resistance.	
Segment G: Series Circuits	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. d. Plan and carry out an investigation of the relationship between voltage, current, and power for direct current circuits. (Clarification statement: Application of Ohm's Law to different circuit configurations, not limited to parallel and series, and calculations of equivalent resistance are expected).	SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism. b. Develop and use models to illustrate and explain the conventional flow (direct and alternating) of current and the flow of electrons in simple series and parallel circuits. (Clarification statement: Advantages and disadvantages of series and parallel circuits should be addressed.)	

UNIT 5: ELECTRICITY AND MAGNETISM

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment H: Parallel and Complex Circuits	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. d. Plan and carry out an investigation of the relationship between voltage, current, and power for direct current circuits. (Clarification statement: Application of Ohm's Law to different circuit configurations, not limited to parallel and series, and calculations of equivalent resistance are expected.)	SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism. b. Develop and use models to illustrate and explain the conventional flow (direct and alternating) of current and the flow of electrons in simple series and parallel circuits. (Clarification statement: Advantages and disadvantages of series and parallel circuits should be addressed.)	
Segment I: Electrical Power	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. d. Plan and carry out an investigation of the relationship between voltage, current, and power for direct current circuits. (Clarification statement: Application of Ohm's Law to different circuit configurations, not limited to parallel and series, and calculations of equivalent resistance are expected.)		
Segment J: Magnetism	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. e. Plan and carry out investigations to clarify the relationship between electric currents and magnetic fields. (Clarification statement: This includes coils and their importance in the design of motors and generators.)	SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism. c. Plan and carry out investigations to determine the relationship between magnetism and the movement of electrical charge. (Clarification statement: Investigations could include electromagnets, simple motors, and generators.)	S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature. a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact.

UNIT 5: ELECTRICITY AND MAGNETISM

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment K: Generators and Motors	SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions. e. Plan and carry out investigations to clarify the relationship between electric currents and magnetic fields. (Clarification statement: This includes coils and their importance in the design of motors and generators.)	SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism. c. Plan and carry out investigations to determine the relationship between magnetism and the movement of electrical charge. (Clarification statement: Investigations could include electromagnets, simple motors, and generators.)	S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature. a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact. c. Plan and carry out investigations to identify the factors (e.g., distance between objects, magnetic force produced by an electromagnet with varying number of wire turns, varying number or size of dry cells, and varying size of iron core) that affect the strength of electric and magnetic forces. (Clarification statement: Including, but not limited to, generators or motors.)

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: The Nature of Waves	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. a. Develop and use mathematical models to explain mechanical and electromagnetic waves as a propagating disturbance that transfers energy. (Clarification statement: Mathematically describe how the velocity, frequency, and wavelength of a propagating wave are related.) c. Construct an argument that analyzes the production and characteristics of sounds waves. (Clarification statement: Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.) d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. a. Analyze and interpret data to identify the relationships among wavelength, frequency, and energy in electromagnetic waves and amplitude and energy in mechanical waves. b. Ask questions to compare and contrast the characteristics of electromagnetic and mechanical waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction. d. Analyze and interpret data to explain how different media affect the speed of sound and light waves.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. a. Ask questions to develop explanations about the similarities and differences between electromagnetic and mechanical waves. (Clarification statement: Include transverse and longitudinal waves and wave parts such as crest, trough, compressions, and rarefactions.) b. Construct an explanation using data to illustrate the relationship between the electromagnetic spectrum and energy. c. Design a device to illustrate practical applications of the electromagnetic spectrum (e.g., communication, medical, military). d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.) e. Analyze and interpret data to predict patterns in the relationship between density of media and wave behavior (i.e., speed). f. Develop and use a model (e.g., simulations, graphs, illustrations) to predict and describe the relationships between wave properties (e.g., frequency, amplitude, and wavelength) and energy. g. Develop and use models to demonstrate the effects that lenses have on light (i.e., formation an image) and their possible technological applications.

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment B: Sound Wave Properties	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. a. Develop and use mathematical models to explain mechanical and electromagnetic waves as a propagating disturbance that transfers energy. (Clarification statement: Mathematically describe how the velocity, frequency, and wavelength of a propagating wave are related.) c. Construct an argument that analyzes the production and characteristics of sounds waves. (Clarification statement: Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. a. Analyze and interpret data to identify the relationships among wavelength, frequency, and energy in electromagnetic waves and amplitude and energy in mechanical waves. b. Ask questions to compare and contrast the characteristics of electromagnetic and mechanical waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction. d. Analyze and interpret data to explain how different media affect the speed of sound and light waves.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. a. Ask questions to develop explanations about the similarities and differences between electromagnetic and mechanical waves. (Clarification statement: Include transverse and longitudinal waves and wave parts such as crest, trough, compressions, and rarefactions.) d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.) e. Analyze and interpret data to predict patterns in the relationship between density of media and wave behavior (i.e., speed). f. Develop and use a model (e.g., simulations, graphs, illustrations) to predict and describe the relationships between wave properties (e.g., frequency, amplitude, and wavelength) and energy.
Segment C: Doppler Effect	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. c. Construct an argument that analyzes the production and characteristics of sounds waves. (Clarification statement: Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. e. Develop and use models to explain the changes in sound waves associated with the Doppler Effect.	

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment D: Sound: Diffraction and Interference	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. a. Develop and use mathematical models to explain mechanical and electromagnetic waves as a propagating disturbance that transfers energy. (Clarification statement: Mathematically describe how the velocity, frequency, and wavelength of a propagating wave are related.) b. Develop and use models to describe and calculate characteristics related to the interference and diffraction of waves (single and double slits). c. Construct an argument that analyzes the production and characteristics of sounds waves. (Clarification statement: Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.) g. Plan and carry out investigations to describe changes in diffraction patterns associated with geometry and wavelength for mechanical and electromagnetic waves.	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. a. Ask questions to develop explanations about the similarities and differences between electromagnetic and mechanical waves. (Clarification statement: Include transverse and longitudinal waves and wave parts such as crest, trough, compressions, and rarefactions.) d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.)
Segment E: Sound: Standing Waves and Resonance	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. b. Develop and use models to describe and calculate characteristics related to the interference and diffraction of waves (single and double slits). c. Construct an argument that analyzes the production and characteristics of sound waves. (Clarification statement: Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment F: Electromagnetic Wave Properties	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. a. Develop and use mathematical models to explain mechanical and electromagnetic waves as a propagating disturbance that transfers energy. (Clarification statement: Mathematically describe how the velocity, frequency, and wavelength of a propagating wave are related.) d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. a. Analyze and interpret data to identify the relationships among wavelength, frequency, and energy in electromagnetic waves and amplitude and energy in mechanical waves. b. Ask questions to compare and contrast the characteristics of electromagnetic and mechanical waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction. d. Analyze and interpret data to explain how different media affect the speed of sound and light waves.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. a. Ask questions to develop explanations about the similarities and differences between electromagnetic and mechanical waves. (Clarification statement: Include transverse and longitudinal waves and wave parts such as crest, trough, compressions, and rarefactions.) b. Construct an explanation using data to illustrate the relationship between the electromagnetic spectrum and energy. c. Design a device to illustrate practical applications of the electromagnetic spectrum (e.g., communication, medical, military). d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.) e. Analyze and interpret data to predict patterns in the relationship between density of media and wave behavior (i.e., speed). f. Develop and use a model (e.g., simulations, graphs, illustrations) to predict and describe the relationships between wave properties (e.g., frequency, amplitude, and wavelength) and energy.

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment G: Light: Polarization	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media.		
Segment H: Light: Diffraction and Interference	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. b. Develop and use models to describe and calculate characteristics related to the interference and diffraction of waves (single and double slits). d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) g. Plan and carry out investigations to describe changes in diffraction patterns associated with geometry and wavelength for mechanical and electromagnetic waves.	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.)

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment I: Color	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media.		S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.
Segment J: Spectral Composition	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media.		

Standards Alignment Crosswalk

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment K: Reflection	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media. • Perform calculations related to reflections from plane surfaces and focusing using thin lenses.	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.
Segment L: Spherical Mirrors			

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment M: Refraction	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media. • Analyze experimentally and mathematically aspects of reflection and refraction of light waves and describe the results using optical ray diagrams. f. Plan and carry out investigations to identify the behavior of light using lenses. (Clarification statement: Investigations concerning Snell's Law, optical ray diagrams, and thin lens equation should be conducted.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering.)

UNIT 6: WAVES AND OPTICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment N: Spherical Lenses	SP4. Obtain, evaluate, and communicate information about the properties and applications of waves. d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves. (Clarification statement: Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.) e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media. • Analyze experimentally and mathematically aspects of reflection and refraction of light waves and describe the results using optical ray diagrams. • Perform calculations related to reflections from plane surfaces and focusing using thin lenses. f. Plan and carry out investigations to identify the behavior of light using lenses. (Clarification statement: Investigations concerning Snell's Law, optical ray diagrams, and thin lens equation should be conducted.)	SPS9. Obtain, evaluate, and communicate information to explain the properties of waves. c. Develop models based on experimental evidence that illustrate the phenomena of reflection, refraction, interference, and diffraction.	S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves. d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials. (Clarification statement: Include echo and how color is seen but do not cover interference and scattering. g. Develop and use models to demonstrate the effects that lenses have on light (i.e., formation an image) and their possible technological applications.

UNIT 7: NUCLEAR PHYSICS

Segment	HS Physics Standard	HS Physical Science Standard	MS Physical Science Standard
Segment A: Radioactive Decay	SP6. Obtain, evaluate, and communicate information about nuclear changes of matter and related technological applications. b. Construct an argument to compare and contrast mechanisms and characteristics of radioactive decay.		
Segment B: Fission	SP6. Obtain, evaluate, and communicate information about nuclear changes of matter and related technological applications. a. Develop and use models to explain, compare, and contrast nuclear processes including radioactive decay, fission, and fusion.		
Segment C: Fusion			
Segment D: Half-Life	SP6. Obtain, evaluate, and communicate information about nuclear changes of matter and related technological applications. c. Develop and use mathematical models and representations to calculate the amount of substance present after a given amount of time based on its half-life and relate this to the law of conservation of mass and energy.		