

Physics: Curriculum Guide

Course Description	The Honors Physics course covers mechanics including kinematics, dynamics and mechanical energy, and waves, light, and electromagnetism. Students will use Algebra I and II and Geometry to understand these physics concepts. Lectures, demonstrations and laboratory investigations are used to develop an understanding of essential concepts. Application of the concepts to a wide variety of everyday phenomena is discussed.
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Unit: Kinematics	
Essential Questions	● Why is it important that the motion(s) of an object(s) be described and predicted? ● What is the relationship(s) between the descriptors of motion?
Skills/Standards/Topics	<i>Standards</i> HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force. ● Movement is described by location, motion, the rate motion is changing and frame of reference. ● Motion is a directionally dependent concept. ● Motion can be described by the rate of change. ● Motion can be graphically analyzed by conceptual relationships. ● Vectors are direction-dependent. ● The motion of a projectile can be represented and analyzed as two different motions, a vertical motion with constant acceleration and a horizontal motion with constant speed. Students will be able to... ● Describe locations of objects using relative positions and a frame of reference ● Explain, calculate and apply displacement, distance, velocity, speed, and acceleration when solving problems ● Use information from the various representations of translational motion to solve for unknown motion quantities of objects in translational motion ● Compare and contrast vector and scalar quantities ● Differentiate between uniform and accelerated motion ● Represent and analyze the motion of a projectile as two independent

	perpendicular motions
Resources	

Unit: Newton's Laws	
Essential Questions	● In what ways do forces and the properties of bodies control changes in motion? ● In what ways can an athlete in your sport improve their performance by understanding and applying Newton's three laws of motion?
Skills/Standards/Topics	<i>Standards</i> HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force. HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations. ● There are forces that can and will oppose motion or create changes in motion. ● Newton's second law of motion describes motion and change in motion of objects with inertia when acted on by a net force. ● For every action, there is an equal and opposite reaction. ● Weight is a force governed by gravity. ● The force of friction depends on the nature of the materials in contact and the normal force. Students will be able to... ● Apply Newton's Laws to analyze and solve complex, real-world problems involving forces, motion, and acceleration in one and two dimensions ● Calculate the weight force of an object by understanding the conceptual and mathematical relationship between mass and gravity ● Construct free body diagrams to identify and interpret the magnitude and direction of forces acting on an object, and use this information to predict the object's motion ● Explain how friction forces, including static and kinetic friction, depend on the nature of materials in contact and the normal force, and evaluate the effect of friction in various scenarios ● Combine vector forces to determine the net force acting on an object, and analyze motion down inclines, considering factors like friction,

	air resistance, and fixed connections
Resources	

Unit: Circular Motion and Gravitation	
Essential Questions	● How does the direction of an object's acceleration affect its motion? ● How does the interaction of massive bodies influence their motion?
Skills/Standards/Topics	<i>Standards</i> HS-PS2-4. Use mathematical representations of Newton’s law of gravitation and Coulomb’s law to both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects. ● Objects can accelerate when moving at constant speed. ● Objects moving with constant speed along a circular path accelerate toward the center of the circular path. ● A force perpendicular to an object’s motion is needed to change its direction. ● All objects in the universe possess gravity and attract one another. ● Gravity is an attractive force that is directly related to the mass in each object and indirectly related to the square of the separation distance. ● Planets move in circular orbits due to the attractive pull of gravity. ● A rotating reference frame can give the appearance of an object constrained to travel in a circular path which gives a centripetal acceleration directed from the object toward the center of the rotating reference frame. Students will be able to... ● Differentiate between speed and velocity, and explain how these concepts apply to both uniform linear motion and uniform circular motion ● Calculate the centripetal force acting on an object moving along a circular path with uniform speed, and determine its direction relative to the motion ● Analyze the net force acting on an object in uniform circular motion and predict its impact on the object's trajectory ● Calculate the force of gravity between two objects and explain how this attractive force behaves as a field force. ● Determine the orbital speed of a satellite orbiting a planet and explain how the acceleration due to gravity changes with increased

	distance above the planet's surface
Resources	

Unit: Work and Energy	
Essential Questions	• How is the motion of objects explained, described and predicted by energy transformations? • How does our understanding of Conservation of Energy allow us to better experience the world around us?
Skills/Standards/Topics	<i>Standards</i> HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system. HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields. HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy. • The total amount of energy in a closed system is conserved. • Energy can be transformed from one form to another through interactions. • The conservation laws apply at all scales from very small particles to the entire universe. • Interactions between objects create systems. Students will be able to... • Calculate the work done when a force is applied to the concept of energy transfer • Apply the principle of conservation of energy to calculate the kinetic and potential energy of an object at any point during its motion • Analyze energy transformations in various scenarios, including how some energy is converted into thermal energy during these processes • Differentiate between kinetic energy and potential energy and describe how they are represented and quantified in a system

	● Explain how energy is transferred between objects and/or forms through interactions that involve work, particularly in the context of a closed system
Resources	

Unit: Linear Momentum	
Essential Questions	● How does momentum influence the interaction of bodies? ● How is the center of mass significant for a collection of particles or a single body?
Skills/Standards/Topics	<i>Standards</i> HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system. HS-PS2-3. Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. ● The center of mass of a collection of particles acts as if all the mass is located at that one, single position. ● Momentum quantifies motion both in size and direction. ● An impulse is the product of an applied force and the amount of time the force is applied. ● An impulse acting on an object will change the momentum of an object. ● Momentum in a closed, isolated system of particles is a conserved quantity. Students will be able to... ● Calculate the center of mass of an object both physically and mathematically ● Apply the momentum-impulse theorem to analyze the interactions between two objects during collisions ● Distinguish between elastic and inelastic collisions by identifying key characteristics of each type ● Analyze the collision of two objects, moving in one and two dimensions, using the principle of conservation of momentum.
Resources	

Unit: Heat	
Essential Questions	• How is the motion of objects explained, described and predicted by energy transformations? • How does our understanding of Conservation of Energy allow us to better experience the world around us?
Skills/Standards/Topics	<i>Standards</i> HS-PS3-4a. Provide evidence that when two objects of different temperature are in thermal contact within a closed system, the transfer of thermal energy from higher temperature objects to lower-temperature objects results in thermal equilibrium, or a more uniform energy distribution among the objects and that temperature changes necessary to achieve thermal equilibrium depend on the specific heat values of the two substances. • The total amount of energy in a closed system is conserved. • Energy can be transformed from one form to another through interactions. • The conservation laws apply at all scales from very small particles to the entire universe. • Interactions between objects create systems. Students will be able to... • Explain how energy is transferred between objects and forms during the process of heat transfer and transformation of energy into thermal energy • Calculate the kinetic and potential energy of an object at any point during its motion using the principle of conservation of energy • Analyze how the total energy within a closed system remains constant (conserved) during interactions involving work and energy transfer • Describe the process of reaching thermal equilibrium through the transfer of heat between substances.

Unit: Waves	
Essential Questions	• Why are waves an efficient way to transfer energy and information? • How does resonance impact our world and our interactions?
Skills/Standards/Topics	<i>Standards</i> HS-PS4-1. Use mathematical representations to support a claim regarding

relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by either a wave model or a particle model, and that for some situations involving resonance, interference, diffraction, refraction, or the photoelectric effect, one model is more useful than the other.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

- Mechanical and electromagnetic waves are described in terms of wavelength, amplitude, velocity, and frequency and can be produced by objects in simple harmonic motion or electrical circuits.
- Traveling waves transfer energy exerted as force to distant objects that absorb or reflect the traveling waves.
- The waves interact with other waves and matter and result in the phenomena of wave superposition, interference, reflection, refraction, and resonance.

Students will be able to...

- Describe the relationship between simple harmonic motion and the formation of waves, including how this relationship leads to various wave phenomena
- Apply the concepts of forced vibration and resonance to explain the occurrence of large amplitude vibrations in physical systems, such as earthquakes and musical instruments
- Analyze how wave characteristics like speed, wavelength, and frequency are influenced by the medium through which a wave travels and how these characteristics change when a wave moves from one medium to another
- Compare and contrast the properties of sound waves and light waves, focusing on their physical characteristics and behaviors, including reflection, refraction, and interference
- Explain the Doppler effect and describe how the frequency of a wave appears to change due to the motion of the source or the receiver

Unit: Light

Essential Questions

- **Why do my eyeglasses or contact lenses improve my vision?**

	● How do we use optics to understand or explore the universe?
Skills/Standards/Topics	<i>Standards</i> HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by either a wave model or a particle model, and that for some situations involving resonance, interference, diffraction, refraction, or the photoelectric effect, one model is more useful than the other. HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. ● The ray model for describing the behavior of waves ● The shape of the boundary between the different mediums influences the behavior of the waves that change mediums ● The shape of a reflective surface influences the behavior of the waves when they reflect ● How the combination of optical elements combine to produce unique optical outcomes ● The description of images formed by optical elements Students will be able to... ● Locate and describe the image formed by convex and concave lenses, including the image's size, orientation, and type (real or virtual) ● Locate and describe the image formed by plane, concave, and convex mirrors, detailing the image's characteristics such as position, size, and type (real or virtual) ● Identify and differentiate between real and virtual images, explaining how each type is formed by lenses and mirrors.

Unit: Electricity & Magnetism	
Essential Questions	● How does the understanding of electric charges allow us to better understand natural phenomena? ● How do electric currents impact our everyday life? ● Describe in what ways the relationship between electricity and magnetism impacts the development of the technology we use?
Skills/Standards/Topics	<i>Standards</i> HS-PS2-4. Use mathematical representations of Newton's law of gravitation and Coulomb's law to both qualitatively and quantitatively describe and

predict the effects of gravitational and electrostatic forces between objects.

HS-PS2-5. Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-9(MA). Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit.

HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.

HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS3-5. Develop and use a model of magnetic or electric fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a magnetic or electric field, respectively.

- Moving electrical charges can be used to control electrical energy
- Charges interact with other charges
- The interaction of charges can be represented by fields
- Magnetic and Electrical forces are manifestations of the same fundamental force
- The arrangement of elements in a circuit controls the electrical energy in the circuit

Students will be able to...

- Explain the inverse square relationship of the electrostatic force between two charged particles, and how like charges repel while unlike charges attract
- Differentiate between conductors and insulators by describing their properties and behavior in electric fields
- Apply Ohm's Law to analyze the relationship between voltage, current, and resistance in a DC circuit
- Construct and compare series and parallel circuits, explaining the differences in current, voltage distribution, and resistance
- Demonstrate how a changing magnetic field can induce a current in a wire, and explain the basic principles behind the functioning of motors and generators

Resources