

**SHENENDEHOWA CENTRAL SCHOOL
CLIFTON PARK, NEW YORK
OFFICE OF INSTRUCTIONAL SERVICES
ESSENTIAL CONTENT OF SCIENCE
Physical Setting/Physics**

Key to understanding the document

Process Skills: These process skills should be incorporated into core-based physics curricula. These skills are tied to specific content in the core. During assessments, students will be presented with new situations to analyze and new problems to solve using these process skills.
Performance Indicators: (1.1a, 5.1d, etc.) Refer to the middle and high school New York State Core Curriculum Guide.
EP is Everyday Physics: A check in that column means that content and skill is covered in this non-regents course.
* Starred Concepts: Indicate that there is a related formula available in the reference table to use for calculations.

Standard 4 – Process Skills Checklist	EP
The Standard 4 Process Skills Checklist is intended to be a tool for curriculum development. These process skills should be incorporated into core-based physics curricula. These skills are tied to specific content in the core. During assessments, students will be presented with new situations to analyze and new problems to solve using these process skills. <i>The student will be able to:</i>	
<i>Mechanics</i>	
construct and interpret graphs of position, velocity, or acceleration versus time	
determine and interpret slopes and areas of motion graphs	
determine the acceleration due to gravity near the surface of Earth	
determine the resultant of two or more vectors graphically or algebraically	✓
draw scaled force diagram using a ruler and protractor	
resolve a vector into perpendicular components: both graphically and algebraically	
sketch the theoretical path of a projectile	✓
use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium)	
verify Newton's Second Law for linear motion	✓
determine the coefficient of friction for two surfaces	
verify Newton's Second Law for uniform circular motion	
verify conservation of momentum	✓
determine a spring constant	

Energy	
describe and explain the exchange between potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object	✓
predict velocities, heights, and spring compressions based on energy conservation	
determine the energy stored in a spring	
determine the factors that affect the period of a pendulum	
observe and explain energy conversions in real-world situations	✓
recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery	
compare the power developed when the same work is done at different rates	
Electricity and Magnetism	
measure current and voltage in a circuit	✓
use measurements to determine the resistance of a circuit element	✓
interpret graphs of voltage versus current	
measure and compare the resistance of conductors of various lengths and cross-sectional areas	
construct simple series and parallel circuits	✓
draw and interpret circuit diagrams which include voltmeters and ammeters	✓
predict the behavior of light bulbs in series and parallel circuits	✓
map the magnetic field of a permanent magnet, indicating the direction of the field between the N (north-seeking) and S (south-seeking) poles	
Waves	
compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase	✓
draw wave forms with various characteristics	✓
identify nodes and antinodes in standing waves	
differentiate between transverse and longitudinal waves	✓
determine the speed of sound in air	✓
predict the superposition of two waves interfering constructively and destructively (indicating nodes, antinodes, and standing waves)	✓
observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract	
draw ray diagrams to represent the reflection and refraction of waves	✓
determine empirically the index of refraction of a transparent medium	
Modern Physics	
interpret energy-level diagrams	
correlate spectral lines with an energy-level diagram	

Regents Content	Regents Skills	EP
MECHANICS		
5.1a Measured quantities can be classified as either vector or scalar.		✓
5.1d An object in linear motion may travel with a constant velocity* or with acceleration*. (<i>Note: Testing of acceleration will be limited to cases in which acceleration is constant.</i>)	5.1 Explain and predict different patterns of motion of objects (e.g., linear and uniform circular motion, velocity and acceleration, momentum and inertia). i. construct and interpret graphs of position, velocity, or acceleration versus time ii. determine and interpret slopes and areas of motion graphs iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically vii. sketch the theoretical path of a projectile viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium) ix. verify Newton's Second Law for linear motion x. determine the coefficient of friction for two surfaces xi. verify Newton's Second Law for uniform circular motion xii. verify conservation of momentum xiii. determine a spring constant	✓
5.1e An object in free fall accelerates due to the force of gravity.* Friction and other forces cause the actual motion of a falling object to deviate from its theoretical motion. (<i>Note: Initial velocities of objects in free fall may be in any direction.</i>)	5.1 i. construct and interpret graphs of position, velocity, or acceleration versus time ii. determine and interpret slopes and areas of motion graphs iii. determine the acceleration due to gravity near the surface of Earth x. determine the coefficient of friction for two surfaces	✓
5.1c The resultant of two or more vectors, acting at any angle, is determined by vector addition.	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium)	
5.1b A vector may be resolved into perpendicular components.*	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium)	
5.1f The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently.	5.1.i. construct and interpret graphs of position, velocity, or acceleration versus time ii. determine and interpret slopes and areas of motion graphs vii. sketch the theoretical path of a projectile	✓
5.1g A projectile's time of flight is dependent upon the vertical component of its motion.		✓
5.1h The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight.	5.1 vii. sketch the theoretical path of a projectile	✓

5.1i According to Newton's First Law, the inertia of an object is directly proportional to its mass. An object remains at rest or moves with constant velocity, unless acted upon by an unbalanced force.	5.1 ii. determine and interpret slopes and areas of motion graphs vii. sketch the theoretical path of a projectile ix. verify Newton's Second Law for linear motion xi. verify Newton's Second Law for uniform circular motion	✓
5.1j When the net force on a system is zero, the system is in equilibrium.	5.1 viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium)	✓
5.1k According to Newton's Second Law, an unbalanced force causes a mass to accelerate*.	5.1ix verify Newton's Second Law for linear motion	✓
5.1l Weight is the gravitational force with which a planet attracts a mass*. The mass of an object is independent of the gravitational field in which it is located.	5.1iii determine the acceleration due to gravity near the surface of Earth	✓
5.1o Kinetic friction* is a force that opposes motion.	5.1x determine the coefficient of friction for two surfaces	✓
5.1n Centripetal force* is the net force which produces centripetal acceleration.* In uniform circular motion, the centripetal force is perpendicular to the tangential velocity.	5.1xi verify Newton's Second Law for uniform circular motion	✓
5.1p The impulse* imparted to an object causes a change in its momentum*.	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium) xiii. determine a spring constant	✓
5.1m The elongation or compression of a spring depends upon the nature of the spring (its spring constant) and the magnitude of the applied force.*	5.1 xiii. determine a spring constant	✓
5.1q According to Newton's Third Law, forces occur in action/reaction pairs. When one object exerts a force on a second, the second exerts a force on the first that is equal in magnitude and opposite in direction.	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium) xii. verify conservation of momentum	✓
5.1r Momentum is conserved in a closed system.* (<i>Note: Testing will be limited to momentum in one dimension.</i>)	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium) xii. verify conservation of momentum	✓
5.1t Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive.	5.1 iii. determine the acceleration due to gravity near the surface of Earth iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically	✓

5.1u The inverse square law applies to electrical* and gravitational* fields produced by point sources.	4.1 xv. map the magnetic field of a permanent magnet, indicating the direction of the field between the N (north-seeking) and S (south-seeking) poles	✓
5.1s Field strength* and direction are determined using a suitable test particle. (Notes: 1)Calculations are limited to electrostatic and gravitational fields. 2)The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)	5.1 iv. determine the resultant of two or more vectors graphically or algebraically v. draw scaled force diagrams using a ruler and a protractor vi. resolve a vector into perpendicular components both graphically and algebraically viii. use vector diagrams to analyze mechanical systems (equilibrium and non-equilibrium)	✓
ENERGY		
4.1g When work* is done on or by a system, there is a change in the total energy* of the system.	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object ii. predict velocities, heights, and spring compressions based on energy conservation iv. determine the factors that affect the period of a pendulum vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery 5.1 x. determine the coefficient of friction for two surfaces	✓
4.1h Work done against friction results in an increase in the internal energy of the system.	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object 5.1 x. determine the coefficient of friction for two surfaces.	✓
4.1j Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy.	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object vii. compare the power developed when the same work is done at different rates	✓
4.1a All energy transfers are governed by the law of conservation of energy.*	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery	✓
4.1b Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms.	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object v. observe and explain energy conversions in real-world situations vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery	✓

<p>4.1c Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic*.</p>	<p>4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object ii. predict velocities, heights, and spring compressions based on energy conservation iii. determine the energy stored in a spring iv. determine the factors that affect the period of a pendulum v. observe and explain energy conversions in real-world situations vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery</p>	✓
<p>4.1d Kinetic energy* is the energy an object possesses by virtue of its motion.</p>	<p>4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object ii. predict velocities, heights, and spring compressions based on energy conservation iv. determine the factors that affect the period of a pendulum v. observe and explain energy conversions in real-world situations vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery</p>	✓
<p>4.1e In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.*</p>	<p>4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object ii. predict velocities, heights, and spring compressions based on energy conservation iii. determine the energy stored in a spring vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery 5.1i. construct and interpret graphs of position, velocity, or acceleration versus time ii. determine and interpret slopes and areas of motion graphs</p>	✓
<p>4.1f In a non ideal mechanical system, as mechanical energy decreases there is a corresponding increase in other energies such as internal energy.*</p>	<p>4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object ii. predict velocities, heights, and spring compressions based on energy conservation iii. determine the energy stored in a spring iv. determine the factors that affect the period of a pendulum v. observe and explain energy conversions in real-world situations vi. recognize and describe conversions among different forms of energy in real or hypothetical devices such as a motor, a generator, a photocell, a battery i. construct and interpret graphs of position, velocity, or acceleration versus time ii. determine and interpret slopes and areas of motion graphs x. determine the coefficient of friction for two surfaces</p>	✓

ELECTRICITY		
5.1t Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive.	4.1xv. map the magnetic field of a permanent magnet, indicating the direction of the field between the N (north-seeking) and S (south-seeking) poles	✓
5.1u The inverse square law applies to electrical* and gravitational* fields produced by point sources.		✓
4.1j Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy.	4.1i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object	✓
4.1m The factors affecting resistance in a conductor are length, cross-sectional area, temperature, and resistivity.*	4.1 viii. measure current and voltage in a circuit ix. use measurements to determine the resistance of a circuit element x. interpret graphs of voltage versus current xi. measure and compare the resistance of conductors of various lengths and cross-sectional areas	✓
4.1l All materials display a range of conductivity. At constant temperature, common metallic conductors obey Ohm's Law*.	4.1 viii. measure current and voltage in a circuit ix. use measurements to determine the resistance of a circuit element x. interpret graphs of voltage versus current	✓
4.1n A circuit is a closed path in which a current* can exist. (<i>Note: Use conventional current.</i>)	4.1xii. construct simple series and parallel circuits xiii. draw and interpret circuit diagrams which include voltmeters and ammeters xiv. predict the behavior of light bulbs in series and parallel circuits	✓
4.1p Electrical power* and energy* can be determined for electric circuits.	4.1 viii. measure current and voltage in a circuit ix. use measurements to determine the resistance of a circuit element x. interpret graphs of voltage versus current 1xii. construct simple series and parallel circuits xiv. predict the behavior of light bulbs in series and parallel circuits	✓
4.1o Circuit components may be connected in series* or in parallel*. Schematic diagrams are used to represent circuits and circuit elements.	4.1 xi. measure and compare the resistance of conductors of various lengths and cross-sectional areas xii. construct simple series and parallel circuits xiii. draw and interpret circuit diagrams which include voltmeters and ammeters xiv. predict the behavior of light bulbs in series and parallel circuits	✓
4.1k Moving electric charges produce magnetic fields. The relative motion between a conductor and a magnetic field may produce a potential difference in the conductor.		

WAVES AND LIGHT		
4.3a An oscillating system produces waves. The nature of the system determines the type of wave produced.	4.3 i. compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase ii. draw wave forms with various characteristics iv. differentiate between transverse and longitudinal waves	✓
4.3b Waves carry energy and information without transferring mass. This energy may be carried by pulses or periodic waves.	4.3 i. compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase iv. differentiate between transverse and longitudinal waves	✓
4.3e Waves are categorized by the direction in which particles in a medium vibrate about an equilibrium position relative to the direction of propagation of the wave, such as transverse and longitudinal waves.	4.3 i. compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase ii. draw wave forms with various characteristics iv. differentiate between transverse and longitudinal waves	✓
4.3d Mechanical waves require a material medium through which to travel.	4.3 i. compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase iv. differentiate between transverse and longitudinal waves	✓
4.3c The model of a wave incorporates the characteristics of amplitude, wavelength,* frequency*, period*, wave speed*, and phase.	4.3 i. compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase iv. differentiate between transverse and longitudinal waves v. determine the speed of sound in air vi. predict the superposition of two waves interfering constructively and destructively (indicating nodes, antinodes, and standing waves)	✓
4.3g Electromagnetic radiation exhibits wave characteristics. Electromagnetic waves can propagate through a vacuum.		✓
4.3k All frequencies of electromagnetic radiation travel at the same speed in a vacuum.*	4.3 vii. observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract viii. draw ray diagrams to represent the reflection and refraction of waves	✓
4.3h When a wave strikes a boundary between two media, reflection*, transmission, and absorption occur. A transmitted wave may be refracted.	4.3 vii. observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract viii. draw ray diagrams to represent the reflection and refraction of waves	✓
4.3i When a wave moves from one medium into another, the wave may refract due to a change in speed. The angle of refraction (measured with respect to the normal) depends on the angle of incidence and the properties of the media (indices of refraction).*	4.3 vii. observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract viii. draw ray diagrams to represent the reflection and refraction of waves ix. determine empirically the index of refraction of a transparent medium	✓
4.3j The absolute index of refraction is inversely proportional to the speed of a wave.*	4.3 vii. observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract viii. draw ray diagrams to represent the reflection and refraction of waves ix. determine empirically the index of refraction of a transparent medium	

4.3m When waves of a similar nature meet, the resulting interference may be explained using the principle of superposition. Standing waves are a special case of interference.	4.3ii. draw wave forms with various characteristics iii. identify nodes and antinodes in standing waves vi. predict the superposition of two waves interfering constructively and destructively (indicating nodes, antinodes, and standing waves)	✓
4.3f Resonance occurs when energy is transferred to a system at its natural frequency.	4.3 ii. draw wave forms with various characteristics iii. identify nodes and antinodes in standing waves iv. differentiate between transverse and longitudinal waves vi. predict the superposition of two waves interfering constructively and destructively (indicating nodes, antinodes, and standing waves) 5.3 i. interpret energy-level diagrams ii. correlate spectral lines with an energy-level diagram	✓
4.3l Diffraction occurs when waves pass by obstacles or through openings. The wavelength of the incident wave and the size of the obstacle or opening affect how the wave spreads out.	4.3 vii. observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract	✓
4.3n When a wave source and an observer are in relative motion, the observed frequency of the waves traveling between them is shifted (Doppler effect).		✓
MODERN PHYSICS		
5.3a States of matter and energy are restricted to discrete values (quantized).		
5.3b Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the sub nuclear level, charge appears as fractional values of the elementary charge (quarks).		
5.3c On the atomic level, energy is emitted or absorbed in discrete packets called photons.*		
5.3d The energy of a photon is proportional to its frequency.*		
5.3e On the atomic level, energy and matter exhibit the characteristics of both waves and particles.		
5.3f Among other things, mass-energy and charge are conserved at all levels (from sub nuclear to cosmic).		
5.3g The Standard Model of Particle Physics has evolved from previous attempts to explain the nature of the atom and states that:		

5.3g • atomic particles are composed of sub nuclear particles		
5.3g • the nucleus is a conglomeration of quarks which manifest themselves as protons and neutrons		
5.3g • each elementary particle has a corresponding antiparticle		
5.3h Behaviors and characteristics of matter, from the microscopic to the cosmic levels, are manifestations of its atomic structure. The macroscopic characteristics of matter, such as electrical and optical properties, are the result of microscopic interactions.		
5.3i The total of the fundamental interactions is responsible for the appearance and behavior of the objects in the universe.		
5.3j The fundamental source of all energy in the universe is the conversion of mass into energy.*		