Honors Physics-9

Summit High School
Summit, NJ

Grade Level / Content Area:

9th Grade
Honors Physics

Developed by
Jeremy Morman
Summit High School
2010-2011

Length of Course: 1 year
Summit High School
Summit, NJ

9th Grade Honors Physics

Course Description: Physics is the science of matter and energy, space and time. As the most fundamental science, physics provides a supporting foundation for the other natural sciences, such as chemistry, biology, astronomy, and environmental science. Studying physics is key for understanding natural laws that govern the very big, the very small, and everything between. Students enrolled in this course will investigate waves, sound, light, optics, motion, forces, momentum, energy, gravitation, electricity, magnetism, atomic structure, circuits, and the nucleus. Frequent inquiry-based laboratory activities form a real-world anchor for abstract concepts.

Students in Honors Physics-9 will continuously apply high school level mathematics in problem solving and experimental investigations. Proficient fluency in fundamental algebra is required for success in this course. Useful geometric and trigonometric principles will be introduced and applied where necessary. Honors Physics-9 provides an excellent foundation for students who continue to AP Biology, AP Chemistry, and AP Physics in subsequent years.

Course of Study

Unit 1: The Scientific Method
Science as a process
Measurement
Inquiry based experimentation

Unit 2: Waves and Optics
Waves: Characteristics and calculations
Mechanical waves
Sound
Electromagnetic waves: Light
Reflection and Refraction
Diffraction and Interference
Optical instruments

Unit 3: Motion in One and Two Dimensions
Constant velocity motion
Constant acceleration motion
Freefall
Motion Graphing

Unit 4: Newtonian Dynamics
  Newton’s First Law- Inertia
  Newton’s Second Law
    Friction
  Newton’s Third Law- Action Reaction and Momentum
  Centripetal Force
  Gravitation and Kepler’s Laws

Unit 5: Work and Energy
  Definition of work
  Energy: Kinetic and Potential
  Application of the work energy theorem

Unit 6: Electrostatics and Atomic Structure
  Electrostatic forces
  Coulomb’s Law
  The Bohr Model

Unit 7: Electromagnetism and Circuits
  Magnetic and electromagnetic phenomena
  Circuits

Unit 8: The Atomic Nucleus
  Nuclear structure and forces
  Radioactivity
  Nuclear Applications
# Unit 1
Honors Physics: The Scientific Method

## NJ SCIENCE STANDARD 5.1 Scientific Processes

All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results.

## Big Ideas: The Scientific Method

The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

## Essential Questions

*What provocative questions will foster inquiry, understanding, and transfer of learning?*

- Does science ever prove anything?
- What is science?
- Are all scientific theories true?
- Do the statistics tell the whole story?
- Can we throw away data?
- What makes an experiment “scientific”?

## Enduring Understandings

*What will students understand about the big ideas?*

Students will understand that….

- Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.
- Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.
- Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.
- Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.
• Mathematical tools and technology are used to gather, analyze, and communicate results.

• Empirical evidence is used to construct and defend arguments.

• Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

• Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

• Data and refined models are used to revise predictions and explanations.

• Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

• Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

• Science involves using language, both oral and written, as a tool for making thinking public.

• Ensure that instruments are properly cared for.

• Understand, evaluate and practice safe procedures for conducting science investigations.
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<th>Areas of Focus: Proficiencies (Cumulative Progress Indicators)</th>
<th>Examples, Outcomes, Assessments</th>
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<tr>
<td>NJCCCS CPI #'s:</td>
<td>Instructional Focus</td>
</tr>
<tr>
<td>5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.</td>
<td>- Observational skills and deductive reasoning.</td>
</tr>
<tr>
<td>5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.</td>
<td>- Units, standards, and appropriate recording of data</td>
</tr>
<tr>
<td>5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.</td>
<td>- Experimental design and the testing of hypotheses.</td>
</tr>
<tr>
<td>5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.</td>
<td>Sample Assessments:</td>
</tr>
<tr>
<td>5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.</td>
<td>- Design an experiment to determine which variables change the period of a pendulum.</td>
</tr>
<tr>
<td>5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.</td>
<td>- Approaching everyday problem scenarios using a scientific approach.</td>
</tr>
<tr>
<td>5.1.12.C.1 Reflect on and revise understandings as new evidence emerges.</td>
<td>- Write a procedure that can be carried out by another lab group with a different variable.</td>
</tr>
<tr>
<td>Instructional Strategies:</td>
<td>- Analysis of the period of a spring.</td>
</tr>
<tr>
<td>Interdisciplinary Connections</td>
<td>- Repeat procedures done with the pendulum with a spring a an assessment</td>
</tr>
<tr>
<td>Writing: sufficient technical writing to achieve procedural objective</td>
<td></td>
</tr>
<tr>
<td>Mathematics: Statistical analysis of data collected.</td>
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<tr>
<td>History: Development of the pendulum clock and its importance for world civilization</td>
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<tr>
<td>Technology Integration</td>
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<tr>
<td>Use spreadsheet and other analysis tools to examine the relationships</td>
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<td>Global Perspectives</td>
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<td>Explore data at higher elevation.</td>
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<tr>
<td>5.1.12.C.2</td>
<td>Use data representations and new models to revise predictions and explanations.</td>
</tr>
<tr>
<td>5.1.12.C.3</td>
<td>Consider alternative theories to interpret and evaluate evidence-based arguments.</td>
</tr>
<tr>
<td>5.1.12.D.1</td>
<td>Engage in multiple forms of discussion in order to process, make sense of, and learn from others’ ideas, observations, and experiences.</td>
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<tr>
<td>5.1.12.D.2</td>
<td>Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.</td>
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<tr>
<td>5.1.12.D.3</td>
<td>Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.</td>
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Unit 2
Honors Physics: Waves and Optics

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<th>NJ Science Standard 5.2 Physical Science:</th>
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<td>All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.</td>
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**Big Ideas: Waves and Optics**

The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Energy cannot be created or destroyed but can be transferred from one form to another.

Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions.

Waves transfer energy without transferring matter and serve as a powerful tool for explaining certain properties of sound and electromagnetic radiation.

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<td><em>What provocative questions will foster inquiry, understanding, and transfer of learning?</em></td>
<td><em>What will students understand about the big ideas?</em></td>
</tr>
<tr>
<td>• What is light?</td>
<td>Students will understand that...</td>
</tr>
<tr>
<td></td>
<td>• Waves transfer energy without</td>
</tr>
<tr>
<td>Why do waves break on the shore?</td>
<td>transferring matter.</td>
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<td>---------------------------------</td>
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<tr>
<td>Why is it quiet after a snowfall?</td>
<td>Waves can be described in terms of wavelength, frequency, amplitude, and energy.</td>
</tr>
<tr>
<td>Why do objects appear shifted in position under water or bend as they enter the water?</td>
<td>Waves tend to travel at constant speed through media of constant consistency; the speed of a wave depends only on the physical properties of the medium in which it propagates; the speed of a wave tends to be a function of the density of the medium; the speed of a wave is independent of the characteristics of the wave, such as wavelength, amplitude, and frequency.</td>
</tr>
<tr>
<td>What is a rainbow?</td>
<td>Mechanical waves can exhibit reflection, refraction, diffraction, and interference.</td>
</tr>
<tr>
<td>In what ways does light behave like a wave?</td>
<td>The speed, wavelength and frequency of waves are interrelated.</td>
</tr>
<tr>
<td>Is it possible to hear in outer space?</td>
<td>Average speed is a distance divided by a time interval.</td>
</tr>
<tr>
<td>Why does light, but not sound, travel through outer space?</td>
<td>Sound waves are pressure waves moving through media.</td>
</tr>
<tr>
<td>How do we see a mirage?</td>
<td>Our perception of loudness is related to amplitude while our perception of pitch is related to frequency. The human auditory system is not a true interpreter of sound wave amplitude or frequency.</td>
</tr>
<tr>
<td></td>
<td>Relative motion between receiver and source can cause perceptible apparent changes in wave properties, such as frequency.</td>
</tr>
<tr>
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<td>All electromagnetic waves, including visible light, travel at</td>
</tr>
</tbody>
</table>
Visible light waves comprise a small part of the electromagnetic spectrum. Our perception of color is related to wavelength.

Light rays tend to travel in straight lines but can change direction when reflecting from surfaces of refracting through transparent mediums, providing the possibility of real or virtual images.

The refracted angle of a light wave from one transparent medium into another can be predicted exactly with Snell’s Law.

Light waves exhibit wavelike properties, seen in diffraction and interference effects.

Lenses and mirrors are useful and ubiquitous devices, found in eyeglasses, the human eye, microscopes, binoculars, cameras, telescopes, etc.

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<tr>
<td><strong>5.2.2.C.2</strong> An object can be seen when light strikes it and is reflected to a viewer's eye. If there is no light, objects cannot be seen.</td>
<td>• Wave experiments using water wave tables and mechanical devices such as long springs. Observing wave speeds, different types of waves, and various wave phenomena, such as reflection, refraction, diffraction, and interference.</td>
</tr>
<tr>
<td><strong>5.2.4.C.4</strong> Light travels in straight lines. When light travels from one substance to another (air and water), it changes direction.</td>
<td>• Sound demonstrations of different frequencies and intensities, the Doppler effect, and other sound</td>
</tr>
<tr>
<td><strong>5.2.6.C.1</strong> Light travels in a straight line until it interacts with an object or</td>
<td></td>
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Light can be absorbed, redirected, bounced back, or allowed to pass through. The path of reflected or refracted light can be predicted.

**5.2.6.C.2** Visible light from the Sun is made up of a mixture of all colors of light. To see an object, light emitted or reflected by that object must enter the eye.

**5.2.4.E.1** Motion can be described as a change in position over a period of time.

Furthermore, students will:

- Observe that waves can affect objects across distances through a medium without the direct transfer of any matter.
- Produce and observe pulse, periodic, longitudinal, transverse, and standing waves and measure their characteristics.
- Compare and contrast mechanical waves with electromagnetic waves.
- Produce and observe various types of longitudinal and transverse waves.
- Categorize wave types as either longitudinal or transverse.
- Cite evidence that mechanical waves require media while electromagnetic waves do not.
- Measure wavelength, frequency, and amplitude of various types of waves and label those parts on a diagram.

- Optics experiments using plane and curved mirrors, refractive blocks and prisms, and positive and negative lenses. Students will observe the reflection and refraction of light and real and imaginary images.

**Sample Assessments:**

- Calculate wavelengths, frequencies, or velocities with the wave equation.
- Measure wave characteristics on a slinky.
- Predict reflection and refraction angles using exact mathematical relationships.
- Distinguish between real/virtual, inverted/upright, magnified/reduced images and predict what types of images will appear for given situations.
- Trace rays to locate real and virtual images.
- Predict changes in apparent wavelength and frequency due to relative motion (the Doppler effect).
- Explain wavelike properties of light, especially as demonstrated with a diffraction grating (as prerequisite for emission spectra experiments in Unit-6)

**Instructional Strategies:**

**Interdisciplinary Connections**

- Mathematics: algebraic manipulation of single variable equations (average speed, wave equation)
- History: development of measurements of the speed of light
- Biology: how eyes and ears function
• Observe for various types of waves that wave velocity is only a function of the medium and explain why this fact is important for the enjoyment of music.

• Calculate wave speeds, wavelengths, or frequencies for problems or predictions.

• Cite evidence from observations that mechanical waves tend to travel with a constant speed.

• Explain, in terms of density, why sound waves move more quickly through liquids and solids, and why light waves move fastest through a vacuum.

• Calculate average speeds, distances, and times for constant velocity motion based on experiments and problems.

• Describe pitch and volume changes in terms of frequency and amplitude changes.

• Compare energy intensities with the decibel scale and make connections with the Richter scale.

• Predict changes in apparent received pitch for various relative motion situations.

• Describe colors in terms of wavelength, and visible light’s wavelength within the context of the larger EM spectrum.

• Explain reflection and refractions in terms of Huygen’s principle and

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**Technology Integration**

• Use cell phone cameras to capture data about wave table shadows

• Use computer based data collection software for sound and light demonstrations

• Utilize lasers for refraction and reflection demonstrations.

• Research the history of light theories on the internet.

**Global Perspectives**

• Speed of light as *universal* constant for electromagnetic radiation

• 2005 Indonesian tsunami and other tidal waves; ocean waves on shores around the world

• Archimedes lens weapon (Mythbusters episode)

• Color as a diversely perceived feature historically, culturally, and by different species.

• Light as a cultural metaphorical construct
- Verify Snell’s Law for refracted angles for various optical media, such as glass, water, and oil.
- Calculate wavelength of monochromatic source(s) using a diffraction grating and equations.
- Predict and observe image characteristics using ray diagrams for light that has reflected from plane or spherical mirrors or refracted through transparent materials or lenses.
- Explain the optical function of common optical systems, such as microscopes, magnifying glasses, and the human eye based on fundamental physical concepts.
Unit 3
Honors Physics: Motion in One and Two Dimensions

NJ Science Standard: 5.1 Scientific Processes
All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results.

NJ Science Standard: 5.2 Physical Science:
All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

Big Ideas: Motion in One and Two Dimensions
The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions.

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<td>What will students understand about the big ideas?</td>
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<tr>
<td>• Who is really moving?</td>
<td>Students will understand that…</td>
</tr>
<tr>
<td>• When can you see acceleration?</td>
<td>• An object is in motion when its position is changing. The speed of an object is defined by how far it travels divided by the amount of time it took to travel that far.</td>
</tr>
<tr>
<td>• Are there places we can’t travel to?</td>
<td>• The motion of an object can be described by its position and</td>
</tr>
<tr>
<td>• How do trajectories change as we move through the universe?</td>
<td></td>
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<tr>
<td>• How did a cannoneer predict the</td>
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</table>
An object’s position can be described by locating the object relative to other objects or a background. The description of an object’s motion from one observer’s view may be different from that reported from a different observer’s view.

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<td>Students will:</td>
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<tr>
<td>5.2.8.E.1 Calculate the speed of an object when given distance and time.</td>
<td>• Measuring the relationship between the position of moving objects and the elapsed in time.</td>
</tr>
<tr>
<td>5.2.12.E.1 Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values.</td>
<td>• Graphing the relationship between the position of moving objects and the elapsed in time.</td>
</tr>
<tr>
<td>5.2.6.E.1 Model and explain how the description of an object’s motion from one observer’s view may be different from a different observer’s view.</td>
<td>• Describing the slope of a position vs time curve as instantaneous or average velocity.</td>
</tr>
</tbody>
</table>

- Describing the area under a velocity vs. time curve as displacement.
- Calculating the relationship between the position of moving objects and the elapsed in time.
- Drawing a clear distinction between the concepts of velocity and acceleration.
- Relate velocity and acceleration to natural motions such as simple harmonic motion of a mass-spring system and a pendulum.
- Describe, calculate, and graph the motion of an object caused by the acceleration due to gravity of another object (Earth, moon, sun, etc.).
- Simple projectile motion can be described by independent
horizontal and vertical motions.
- Predict the trajectory characteristics of any projectile knowing its initial height, speed, and angle.
- The motion of an object measured by an observer is relative to that observer's frame of reference.
- Observers in different reference frames will have different measures of the motion of an object

Sample Assessments:
- Measure the distance and time that various objects move in and outside the classroom
- Describe the distinction between distance and displacement
- Calculate speed, velocity, and acceleration for objects moving under uniform acceleration
- Graph distance vs. time and displacement vs. time for objects moving at constant velocity.
- Graph distance vs. time, velocity vs. time and acceleration vs. time for objects moving under uniform acceleration.
- Analyze motion graphs for objects moving under uniform acceleration, and describe the motion that is represented by the graph.
- Calculate velocities using slopes of position vs. time graphs and displacements using the area of a velocity vs time graph.
- Describe and calculate the trajectory, position, velocity, acceleration, and time in the air of a vertical projectile near the surface of the Earth.
- Describe and calculate the trajectory, position, velocity, acceleration, and time in the air of a horizontal projectile near the surface of the Earth.
• Describe and calculate the trajectory characteristics (maximum height, range, time of flight) for general projectile cases.
• Describe and calculate the position and velocity of a moving object as seen from two different reference frames.

Labs:
• Constant velocity/accel running
• Student Motion graphing (sonic detectors and computers)
• Diluted gravity: ball rolling down incline or car along track (photogates or sonic detectors and computers)
• Measuring g: various experiments, perhaps inquiry
• Spaced washers (inverse square relationship)
• Projectiles inquiry lab
• Projectiles: money and hunter:
• Experimental verification that simple projectile motion can be described as the combination of separate horizontal and vertical motions

Instructional Strategies:

Interdisciplinary Connections
• Astronomy: Relative distances and velocities.
• Math: Slopes of lines, averages, scatter plotting, quadratic formula.
• History: Galileo’s use of a pendulum to measure time enabled much more accurate naval navigation and exploration.
• History: Knowledge of velocity, distance and time allowed the ancient Greeks to accurately estimate the circumference of the
Earth

**Technology Integration**
- Use motion sensors, photo gates, and video cameras to record motion data.
- Use computers to store motion data, and calculate displacements, velocities, and accelerations.

**Global Perspectives**
- Explore travel distances and velocities of various modes of transportation.
- Explore travel distances and velocities of peoples from various societies today and in the past.
- Explore travel direction, distances and velocities of oil from the 2010 Gulf Oil Spill.
- Explore the concept of planetary travel to the Moon, Mars, and beyond
Unit 4
Honors Physics: Newtonian Dynamics

NJ Science Standard: 5.1 Scientific Processes
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NJ Science Standard: 5.2 Physical Science
All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

Big Ideas: Newtonian Dynamics
The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions.

Matter is atomic; it has inertia; and it is fundamentally related to the phenomenon of gravitation.

The universe has four fundamental forces; Newton’s laws of motion predict how forces affect the behavior of objects on the macroscopic scale.

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</table>
| • What is inertia? | Students will understand that….
| • Why are seatbelts and airbags necessary? | • Forces have magnitude and direction. Forces vectors can be added. The net force on an object is the sum of all the forces acting on |
| • What is the difference between an object in motion and an object at | |

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<th>Answer</th>
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<tr>
<td>What factors affect the amount of friction or air drag between objects?</td>
<td>- A free body diagram is a useful starting place for analyzing static and dynamic physical situations.</td>
</tr>
<tr>
<td>What do Conservation Laws have to do with Newton's Laws?</td>
<td>- An object at rest will remain at rest unless acted on by an unbalanced force; an object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force.</td>
</tr>
<tr>
<td>What does a spaceship push on in the vacuum of space?</td>
<td>- Mass is a direct measurement of inertia, resistance to acceleration.</td>
</tr>
<tr>
<td>How did Newton put a man on the moon?</td>
<td>- The motion of an object changes only when a net force is applied.</td>
</tr>
<tr>
<td>How do car crash investigators reconstruct the elements of an accident?</td>
<td>- During interactions every action force is countered by an equal and opposite reaction force.</td>
</tr>
<tr>
<td>How is momentum conserved when an object accelerates toward the Earth?</td>
<td>- The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship ((a=\frac{F_{\text{net}}}{m})) is independent of the nature of the force.</td>
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<td></td>
<td>- Masses are affected by the Earth’s gravity, a more or less constant rate of acceleration near its surface. An object’s weight is a measurement of the force of gravity acting on it.</td>
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<tr>
<td></td>
<td>- Friction and fluid drag forces tend to slow or prevent the motion of objects.</td>
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<tr>
<td></td>
<td>- Momentum is the product of an object’s mass and velocity. During isolated interactions, the total momentum of a system is conserved.</td>
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</table>
- The Law of Conservation of Linear Momentum is derived from Newton’s Laws of motion.
- The impulse acting on an object is equal to the change in its momentum.
- An inward “centripetal force” is required to keep bodies in circular motion because their direction is always changing.
- The force of gravitation between two bodies is directly proportional to their masses and inversely proportional to the square of the distance between them.
- Kepler's Laws describe the orbits of bodies in space; Kepler's Laws can be derived using Newton's Laws of Motion.

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<td>5.2.12.D.4 Energy may be transferred from one object to another during collisions.</td>
<td>- Explore meaning of mass as a measurement of inertia by shaking (accelerating) a series of different masses from side to side, discussing the difference between mass and weight.</td>
</tr>
<tr>
<td>5.2.4.E.4 Earth pulls down on all objects with a force called gravity. Weight is a measure of how strongly an object is pulled down toward the ground by gravity. With a few exceptions, objects fall to the ground no matter where they are on Earth.</td>
<td>- Apply Newton’s laws to concrete everyday situations, such as riding in a car with and without a seatbelt.</td>
</tr>
<tr>
<td>5.2.6.E.3 Friction is a force that acts to slow or stop the motion of objects.</td>
<td>- Use inquiry based experiments to investigate the relationship of mass and force on accelerations, action-reaction pairs, and physical variables that affect friction and air resistance.</td>
</tr>
<tr>
<td>5.2.8.E.2 Forces have magnitude and direction. Forces can be added. The net force on an object is the sum of all the forces acting on the object. An object at rest will remain at rest unless</td>
<td>- To observe the Law of Conservation of Linear Momentum in various situations.</td>
</tr>
</tbody>
</table>
acted on by an unbalanced force. An object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force.

**5.2.12.E.2** Objects undergo different kinds of motion (translational, rotational, and vibrational).

**5.2.12.E.4** The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship \( a = \frac{F_{\text{net}}}{m} \) is independent of the nature of the force.

Furthermore, students will:

- Describe the effect on motion of objects in terms of forces.
- Compare forces of different magnitudes and common vs SI units for force.
- Calculate the net force resulting from force combinations.
- Draw free body diagrams for objects in static and dynamics situations.
- Compare the motion of an object acted on by balanced forces with the motion of an object acted on by unbalanced forces in a given specific scenario.
- Describe motion and changes in motion in terms of Newton’s Three Laws.
- Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion.
- Measure and describe the relationship between the force acting on an object and the resulting acceleration.
- Identify action-reaction pairs.
- Define mass in terms of inertia.
- Measure weight and show that it is

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**Sample Assessments:**

- Multiple choice items from textbook test banks.
- Drawing freebody diagrams to predict object motion and changes in motion.
- Solve simple and complex dynamics problems using Newton’s Laws.
- Apply dynamics concepts to uniform circular motion.
- Apply the Impulse-Momentum theorem and Conservation of Momentum to interaction situations.
- Calculate the gravitational force between pairs of masses.

**Instructional Strategies:**

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**Interdisciplinary Connections**

- Mathematics: algebraic manipulation of single variable equations (average speed, wave equation); solution of systems of two equations using substitution or elimination
- History: put Isaac Newton’s 1687 magnum opus, *The Principia*, into its historical context; frame Copernicus, Brahe, Kepler, and Newton in their historical context
- Biology: Discuss the maximum boundaries of acceleration on the human body, particularly in roller coasters, airplanes, and spaceships.
- Sports: describe collisions in various sports (football, billiards, auto racing) in terms of momentum

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**Plot the path of a planet about the sun using real data and verify Kepler's Laws of planetary motion.**
- Directly proportional to weight.
- Demonstrate and explain the frictional force acting on an object with the use of a physical model.
- Identify and measure the effects, if any, that weight, roughness, surface area, and speed have on friction forces.
- Solve dynamics problems with friction.
- Observe various types of collisions and explosions, explain results in terms of energy and momentum conservation.
- Relate impulse with change in momentum.
- Solve 2-D momentum conservation problems by solving a system of equations.
- Verify the centripetal force rule experimentally.
- Apply Newton’s Laws to uniform circular motion cases.
- Understand the basis for Kepler’s Laws of Planetary Motion in terms of Newton’s Laws.

### Technology Integration
- Collect force data using computer based lab devices
- Using infrared based timing devices to measure velocity
- Research applications of Newton’s laws on the internet

### Global Perspectives
- The laws of mechanics—equivalent throughout the universe—transcend geographical and cultural borders.
- Inertia and relative motion as a reference frame phenomena—metaphor for Point of View.
- Historical background of Newton’s life and work
Unit 5
Honors Physics: Work and Energy

**NJ Science Standard: 5.1 Scientific Processes**
All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results.

**NJ Science Standard 5.2 Physical Science:**
All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

**Big Ideas: Work and Energy**
The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Energy cannot be created or destroyed but can be transferred from one form to another.

Understanding of energy conservation and the laws of thermodynamics will enable students to make informed decisions and judgments relevant to important social and scientific issues.

<table>
<thead>
<tr>
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<tbody>
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<td><em>What provocative questions will foster inquiry, understanding, and transfer of learning?</em></td>
<td><em>What will students understand about the big ideas?</em></td>
</tr>
<tr>
<td>• Why does energy seem to be lost in some events and created in others?</td>
<td>Students will understand that…</td>
</tr>
<tr>
<td>• What is an energy transformation?</td>
<td>• Energy cannot be created or destroyed.</td>
</tr>
<tr>
<td>• When mechanical energy is &quot;lost&quot;, where does it go?</td>
<td>• Energy is constantly being transferred and transformed in the natural world.</td>
</tr>
<tr>
<td>Why are the concepts of work and energy necessary and useful to physicists?</td>
<td></td>
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<tr>
<td>Do energy transformations cause disasters?</td>
<td></td>
</tr>
<tr>
<td>Is it possible to break even in during an energy transformation?</td>
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</tr>
<tr>
<td>Can we create a 100% efficient engine?</td>
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</tr>
<tr>
<td>If energy can never be created or destroyed, why is there an “energy crisis”?</td>
<td></td>
</tr>
<tr>
<td>During all energy transformations some energy is lost to disorder.</td>
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</tr>
<tr>
<td>When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. As an object falls, its potential energy decreases as its speed, and consequently its kinetic energy, increases. While an object is falling, some of the object’s kinetic energy is transferred to the medium through which it falls, setting the medium into motion and heating it.</td>
<td></td>
</tr>
<tr>
<td>The potential energy of an object on Earth’s surface is increased when the object’s position is changed from one closer to Earth’s surface to one farther from Earth’s surface.</td>
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</tr>
<tr>
<td>Energy may be transferred from one object to another during collisions.</td>
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<tr>
<td>The net work done on an object during a process is equal to its change in kinetic energy. This is a relationship that can be derived from Newton’s Laws of Motion.</td>
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</tr>
<tr>
<td>Collisions may be classified as elastic or inelastic according to their conservation or loss of mechanical energy.</td>
<td></td>
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<td>Areas of Focus: Proficiencies (Cumulative Progress Indicators)</td>
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<tr>
<td>NJCCCS CPI #'s:</td>
<td>Instructional Focus:</td>
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<tr>
<td>5.2.8.D.1 Relate the kinetic and potential energies of a roller coaster at various points on its path.</td>
<td>- Define work and examine units.</td>
</tr>
<tr>
<td>5.2.12.D.1 Model the relationship between the height of an object and its potential energy.</td>
<td>- Practice describing and calculating the continuous transfer of energy in a closed system.</td>
</tr>
<tr>
<td>5.2.12.D.3 Describe the products and potential applications of fission and fusion reactions.</td>
<td>- Review dynamics problems, including those with friction, using the work-kinetic energy theorem.</td>
</tr>
<tr>
<td>5.2.12.D.4 Measure quantitatively the energy transferred between objects during a collision.</td>
<td>- Apply energy calculations to interaction problems and classify accordingly.</td>
</tr>
<tr>
<td></td>
<td>- Draw parallels between local and universal energy transfers.</td>
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<tr>
<td></td>
<td>- Examine the nuclear reactions in a typical power plant, and the subsequent transfers of energy.</td>
</tr>
<tr>
<td></td>
<td>- Discuss issues surrounding nuclear by-products: handling, storage, security</td>
</tr>
<tr>
<td></td>
<td>Sample Assessments:</td>
</tr>
<tr>
<td></td>
<td>- Identify and describe Potential and Kinetic energy in a variety of natural and designed contexts</td>
</tr>
<tr>
<td></td>
<td>- Describe the process of energy transformation in a variety of natural and designed contexts</td>
</tr>
<tr>
<td></td>
<td>- Explain common natural and designed motions involving energy transformation.</td>
</tr>
<tr>
<td></td>
<td>- Explain and use the Law of Conservation of Energy</td>
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<tr>
<td></td>
<td>- Explain and use the Work-Kinetic Energy Theorem</td>
</tr>
<tr>
<td></td>
<td>- Describe and explain the meaning of energy</td>
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<tr>
<td></td>
<td>- Build a roller coaster that enables a marble to traverse the classroom, and explain the transfer of energy at various key points of the roller coaster.</td>
</tr>
<tr>
<td></td>
<td>- Lab: Predict and measure the kinetic energy gain of a dropped object</td>
</tr>
<tr>
<td>Instructional Strategies: Interdisciplinary Connections</td>
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<tr>
<td>--------------------------------------------------------</td>
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<tr>
<td>- Biological basis of roller coaster design constraints – g forces.</td>
<td></td>
</tr>
<tr>
<td>- Math: Calculations of energies, velocities, forces at various points in a roller coaster.</td>
<td></td>
</tr>
<tr>
<td>- Social studies: How does the existence of high concentrations of potential energy (oil) effect global politics?</td>
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<td>- Use computers to collect data on fast moving objects.</td>
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<tr>
<td>- Use video sources to observe nuclear power plant operations.</td>
</tr>
<tr>
<td>- Use computer simulations to observe and create unique energy transfer systems.</td>
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<td>- Compare and contrast classroom energy transformations with those within our solar system, our galaxy, and the universe.</td>
</tr>
<tr>
<td>- Investigate the geopolitical effects of energy policy.</td>
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# Unit 6
Honors Physics: Electrostatics and Atomic Structure

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**Big Ideas: Electrostatics and Atomic Structure**

The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Matter is atomic; it has inertia; and it is fundamentally related to the phenomenon of gravitation.

The universe has four fundamental forces; Newton’s laws of motion predict how forces affect the behavior of objects on the macroscopic scale.

Electromagnetic and gravitational fields can be used to predict interactions between matter and energy.

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<td><em>What will students understand about the big ideas?</em></td>
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</table>

- When is a scientific theory complete?
- How do we know that atoms exist?
- How big is an atom?

Students will understand that….

- Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons
• What is the most important of the four forces?
• What is a force field?
• Do field lines really exist?

and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.
• The electric (Coulomb’s force) is directly proportional to the magnitudes of the charges and inversely proportional to the distance between them.

• In a neutral atom, a nucleus with positively charged particles is surrounded by an electron cloud with the same number of negatively charged electrons. Gaining or losing electrons electrically charges objects. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.
• The atom has been described by various models through history.
• Bohr’s quantum model of the atom explains to a good approximation emission and absorption spectra.

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<td><strong>Instructional Focus</strong></td>
</tr>
<tr>
<td><strong>5.1.12.A.1</strong> Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.</td>
<td>• Description of an electric charge.</td>
</tr>
<tr>
<td><strong>5.1.12.A.2</strong> Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.</td>
<td>• Electric charge is conserved.</td>
</tr>
<tr>
<td><strong>5.1.12.A.3</strong> Use scientific principles and theories to build and refine standards for data collection, posing controls, and</td>
<td>• Calculation of electric force using Coulomb’s Law. Apply superposition principle for multiple charges.</td>
</tr>
<tr>
<td></td>
<td>• Comparing electric force to gravitational force.</td>
</tr>
<tr>
<td></td>
<td>• Draw and interpret electric field lines.</td>
</tr>
<tr>
<td></td>
<td>• Description of the development of atomic theory from an experimental standpoint through the Bohr atom.</td>
</tr>
</tbody>
</table>
presenting evidence.

5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlation relationships, and anomalous data.

5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.12.C.1 Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Consider alternative theories to interpret and evaluate evidence-based arguments.

5.2.12.A.1 Use atomic models to predict the behaviors of atoms in interactions.

Furthermore, students will:

Recognize the process and the value of scientific review.

Recognize the impact of technology on

Including: Cathode ray tube, oil drop experiment, the gold foil experiment and the Davisson Germer experiment

• Detailed analysis of the Bohr atom, wavelength predictions and failures.
• Descriptions of ions and isotopes and a brief overview of the periodic table.
• Compare and contrast the four fundamental forces and describe their impact on everyday life.

Sample Assessments:
Laboratory experiments
• Electrostatics phenomena (Van der Graaff, electroscopes balloons, rods/fur, etc)
• Using diffraction gratings and the atomic spectrum calculate energy transitions in atoms.
• Electric field hockey (computer)
• Electric field mapping (computer)
• Photoelectric effect

Paper assessments
• Creation of a timeline mapping the development of atomic theory
• Compare and contrast essays on atomic theories.
• Gold foil essay
• Traditional paper assessment

Instructional Strategies:
Interdisciplinary Connections
• History: Integration of atomic theory timeline with historical events from Aristotle to Schroedinger.
• Mathematics: concrete application of an inverse square law.

Technology Integration
• Use of computer simulations to model electric fields.

Global Perspectives
• Exploration of Ancient Greek origin of atomic theory
- Explore similar developments in non-Western cultures.

<table>
<thead>
<tr>
<th>scientific understanding.</th>
<th>Lost the four forces exist in nature and those forces govern the movement of matter and are responsible for nuclear radiation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize that all matter is atomic.</td>
<td>• Explore similar developments in non-Western cultures.</td>
</tr>
</tbody>
</table>

Unit 7
Honors Physics: Electromagnetism and Circuits

NJ Science Standard: 5.1 Scientific Processes
All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results.

NJ Science Standard 5.2 Physical Science:
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Big Ideas: Electromagnetism and Circuits
The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Energy cannot be created or destroyed but can be transferred from one form to another.

The universe has four fundamental forces; Newton’s laws of motion predict how forces affect the behavior of objects on the macroscopic scale.

Electromagnetic and gravitational fields can be used to predict interactions between matter and energy.

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<td>What provocative questions will foster inquiry, understanding, and transfer of learning?</td>
<td>What will students understand about the big ideas?</td>
</tr>
<tr>
<td>• What are the origins of fundamental forces in nature?</td>
<td>Students will understand that…</td>
</tr>
<tr>
<td>• How are contact and field forces related? Does contact really exist?</td>
<td>• Moving electric charges produce magnetic fields.</td>
</tr>
<tr>
<td></td>
<td>• Magnetic fields cause moving electric charges to move.</td>
</tr>
</tbody>
</table>
• How do the fundamental forces shape daily interactions in our lives?

• How do moving electric and magnetic fields cause change?

• How are the relationships between electric and magnetic fields used to shape society?

• How have magnetic fields impacted human history and shed light on the natural history of the earth?

• How do electromagnetic fields affect our world daily?

• Magnetic fields are shaped by the north and south magnetic poles of a magnetized object.

• Magnetic poles always occur in pairs and cannot be separated – unlike electric charge where positive and negative charges can be separated.

• Magnetic poles can attract and repel, as electric charges can.

• Magnetic, electrical, and gravitational forces can act at a distance, and obey the inverse square law.

• The earth has a magnetic field that is detectable at the surface with a compass.

• The earth’s magnetic field has north and south poles and lines of force that are used for navigation.

• Evidence from lava flows and ocean-floor rocks shows that Earth’s magnetic field reverses (North – South) over geologic time.

• The directional relationship between currents, magnetic fields, and magnetic forces can be predicted by the right hand rule.

• Electric motors use magnetic forces to transfer electrical potential energy into kinetic energy.

• Generators use magnetic forces to transfer mechanical energy into electric potential energy.

• The discovery of electrons was accomplished using a magnetic field to deflect cathode rays (J.J. Thomson)

• Electric potential energy difference across a closed conducting circuit will cause charge to flow, producing current.

• Electrical circuits require a complete loop through conducting materials
in which an electrical current can pass.

- All matter has internal resistance to the flow of charge. Resistance depends on the physical properties of matter, the shape and size of the object, and its temperature.
- Current flowing through an object (with resistance) results in the conversion of electrical energy into other forms of energy, such as light, heat, sound, or motion.
- The flow of current in an electric circuit depends upon the components of the circuit and their arrangement, such as in series or parallel. Electricity flowing through an electrical circuit produces magnetic effects.

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<tr>
<td><strong>5.2.6.E.2</strong> Describe the force between two magnets as the distance between them is changed.</td>
<td>- The relationships between electric and magnetic fields.</td>
</tr>
<tr>
<td><strong>5.4.6.D.3</strong> Apply knowledge of Earth’s magnetic fields to successfully complete an orienteering challenge.</td>
<td>- The nature and modeling of magnetic fields.</td>
</tr>
<tr>
<td><strong>5.4.8.D.3</strong> Explain why geomagnetic north and geographic north are at different locations.</td>
<td>- The transfer of electrical and magnetic potential energies into kinetic energy within motors, generators, and circuits.</td>
</tr>
<tr>
<td><strong>5.4.12.D.2</strong> Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data.</td>
<td>- Changing the flow of electrical energy within a circuit by the arrangement of its components.</td>
</tr>
<tr>
<td><strong>5.2.4.D.1</strong> Repair an electric circuit by completing a closed loop that includes wires, a battery (or batteries), and at least one other electrical component to produce observable change.</td>
<td><strong>Sample Assessments:</strong></td>
</tr>
<tr>
<td></td>
<td>- Create an electromagnet with a battery, a nail, and a length of wire</td>
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<tr>
<td></td>
<td>- Describe the relationship between the number of coils in an electromagnet, and the strength of the magnet.</td>
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<tr>
<td></td>
<td>- Create current in a wire using a magnet.</td>
</tr>
</tbody>
</table>
5.2.6.D.1 Use simple circuits involving batteries and motors to compare and predict the current flow with different circuit arrangements

Furthermore, students will:

Model the relationship between the voltage across a circuit and the electrical potential energy converted into kinetic energy (heat, light, sound) by the resistors.

Measure current and voltage with digital multimeters.

- Light a light bulb four ways with minimal circuit components
- Create a variety of series and parallel circuits, after predicting their properties.
- Multiple choice and free response assessments

Labs:

- Measuring current and voltage
- Ohm’s Law
- Series and parallel circuits
- Model and describe magnetic field lines with a bar magnet and iron filings
- Oersted effect or solenoids, electromagnets.
- Mass spec simulator: Angles of deflection of different masses
- Generators & Transformers

Instructional Strategies:

Interdisciplinary Connections

- Biology: biological basis of animal navigation by magnetic fields.
- Astronomy: magnetic fields surrounding the sun and stars, such as neutron stars
- Math: calculations of a circuit’s resistance, voltage and current; algebraic manipulations of simple one-variable, linear equations.
- History: investigate the use of magnetic fields in human navigation over the centuries.
- English: 5 paragraph essay on the Rutherford Gold Foil Experiment

Technology Integration

- Use computers to simulate magnetic field lines and forces.
- Use large classroom audio/visual cathode ray tubes to demonstrate electron deflection by magnetic forces.
<table>
<thead>
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<th><strong>Global Perspectives</strong></th>
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<tbody>
<tr>
<td>● Explore global magnetic fields interacting with solar magnetic winds.</td>
</tr>
<tr>
<td>● Investigate the use of magnetic fields in human navigation over the centuries, and the mapping of local magnetic deviations.</td>
</tr>
<tr>
<td>● Find evidence of the earth’s magnetic field reversing approximately every 10 million years.</td>
</tr>
</tbody>
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### Unit 8
Honors Physics: The Atomic Nucleus

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### Big Ideas: The Atomic Nucleus

The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving.

Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy.

Energy cannot be created or destroyed but can be transferred from one form to another.

Matter is atomic; it has inertia; and it is fundamentally related to the phenomenon of gravitation.

The universe has four fundamental forces; Newton's laws of motion predict how forces affect the behavior of objects on the macroscopic scale.

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- Why are only some substances radioactive?
- Are nuclear power plants a solution

Students will understand that....
- A nucleus is many orders of
to the energy crisis?

- How do scientists “date” old objects? What are the limits of those techniques?
- Is radioactivity good or bad for the human race?
- Why must nuclear decay be understood as a statistical process?
- What is the smallest particle?

- A nucleus is composed of positively charged protons and neutral neutrons.
- A nucleus contains binding energy.
- A radioactive material can emit three different types of radiation: alpha, beta, and gamma.
- The rate of radioactive decay is characterized by half-life.
- Radioactive decay follows a characteristic exponential graph.
- Heavy nuclei can undergo fission, the process of nuclear splitting.
- Light nuclei can undergo nuclear fusion, the process of nuclear binding.
- Nuclear power plants utilize controlled chain reactions, while nuclear bombs rely on uncontrolled chain reactions.
- Nuclear fission is useful for medical applications and for accurately dating archaeological objects.
- The nucleus contains two of the four fundamental forces of nature: the strong force, responsible for binding the nucleus, and the weak force, which is involved with some radioactivity.

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<tr>
<td>5.2.12.A.1 Electrons, protons, and neutrons are parts of the atom and</td>
<td>▪ Explain the function of fission and fusion based nuclear reactors (such as the sun), nuclear weapons,</td>
</tr>
</tbody>
</table>

- magnitude smaller than an atom.
have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.  

5.2.12.A.4 In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.  

5.2.12.D.3 Nuclear reactions (fission and fusion) convert very small amounts of matter into energy.  

Furthermore, students will:  
- Compare the size of a nucleus to other microscopic objects.  
- Compare nuclear properties of different isotopes of an element.  
- Describe uses for released binding energy.  
- Describe the exponential graph of radioactive decay and relate to half-lives.  
- Use understanding of radioactivity and half-lives to analyze dates on archaeological objects.  
- Explain the difference between nuclear fission and fusion.  
- Describe the schematic function of nuclear power plants and nuclear weapons.  
- Compare and contrast the four nuclear medicine, and nuclear dating techniques.  
- Model the random but generally predictable statistical process of nuclear fission.  
- Use mechanical analogies for the nucleus to measure an unknown size indirectly.  
- Understand nuclear changes in terms of the effects of energy transfer.  
- Summarize all of nature’s forces in terms of fundamental forces acting over distances.  

Sample Assessments:  
- Description of an unseen “nucleus” in a mechanical black-box, an activity analogous to the Rutherford experiment.  
- Describe the schematics inner-workings of a fission based nuclear plant.  
- Given a sample’s half-life, predict the shape of its decay graph.  
- Perform calculations with $\frac{1}{2}$-life time and amount of decay.  
- Multiple-choice items from curriculum test banks.  
- Short persuasive essay arguing for or against increased or decreased use of nuclear power in the United States.  
- Use radioactivity knowledge to date an artifact in an hypothetical archaeological situation.  

Instructional Strategies:  
Interdisciplinary Connections  
- Engineering: how nuclear devices work  
- Mathematics: exponential functions  
- Environmental science: environmental pros and cons of nuclear energy
| fundamental forces of nature: gravity, electromagnetism, the strong nuclear force and the weak nuclear force. | • Astronomy: the sun as a fusion engine  
• History: development of nuclear power in the 20th century; effect of nuclear technology on world developments, such as the Cold War  
• Biology: the effects of nuclear radiation on tissue  
• English: Reading of Hiroshima as part of the freshmen curriculum. |
| --- | --- |
| **Technology Integration**  
• Use of a real Geiger counter for radioactive investigations.  
• Statistical analysis utilizing spreadsheet programming and visualization.  
• Computer simulations of nuclear reactors. | **Global Perspectives**  
• Differing perspectives around the world (e.g. France vs. US) on nuclear power.  
• Radioactive natural resources and their relative geographic abundance around the world.  
• Human and geopolitical effects of nuclear weapons, as seen in Japan in 1945 and in the post-war world. |