Integrated Science Unit 1: The Energy of Everyday Physics

Content Area:	**Science**
Course(s):	**Integrated Science**
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NJSLS - Science

SCI.HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
SCI.HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
SCI.HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
SCI.HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
SCI.HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
SCI.HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Science and Engineering Practices

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2), (HS-PS3-5)

Constructing Explanations and Designing Solutions

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS3-3)
- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS- PS2-5)

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2- 1)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2), (HS-PS2-4)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)

- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2), (HS-PS2-3)

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)

- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS- PS2-4), (HS-PS2-5)

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-2)

- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS- PS3-3)

- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

PS3.C: Relationship Between Energy and Forces

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3)

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS- PS2-4)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS- PS2-1), (HS-PS2-5)
- Systems can be designed to cause a desired effect. (HS-PS2-3)
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Theories and laws provide explanations in science. (HS-PS2- 1), (HS-PS2-4)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1), (HS-PS2-4)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)

- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

Rationale and Transfer Goals

One of the goals that Integrated science aims to achieve for students is to show them how important science is to our everyday lives and how it's influences can be seen in many different forms. Of these forms, the flow and uses of energy are of the greatest importance. The purpose of this unit is to introduce students to how energy can be found in the physics of everyday occurrences. After ensuring a strong foundation in Newton's laws and the study of forces, students will learn and demonstrate properties of physics such as the conservation of momentum and energy, the influence of gravity and electrostatic attraction on matter, and how and why forms of matter interact with each other. A strong understanding of these concepts will help students not only in the following units of this class and others, but also in understanding how the world around them works, giving them a greater appreciation of the physical sciences.

Enduring Understandings

- How matter interacts is determined by the electrical forces between and within atoms.

- The motion of an object can be predicted by Newton's Laws.

- Momentum must be conserved.

- Gravity and electrostatic forces can be described by Newton's universal law of gravity and Coulomb's law.

- The properties of matter can be attributed to the attraction and repulsion of electric charges at the atomic scale.

- Energy has many different forms and must be conserved.

Essential Questions

- Why does a high diver go down into a pool instead of just floating into the atmosphere when they jump? (phenomenon)
- Why do belly flops hurt so bad when it's just landing on water? (phenomenon)
- How can the conservation of momentum predict who will hit hardest on the football field? (phenomenon)
- Why does a magnet stick to the fridge but not to me?(phenomenon)
- Is it possible to make energy to power our devices?(phenomenon)

Content - What will students know?

- Newton's second law relates mass and acceleration with the forces acting on the object.
- Momentum is the product of the mass and velocity of an object and must remain conserved in collisions with another object.
- Gravity and electrostatic forces can be described by Newton's universal law of gravity and Coulomb's law
- The properties of matter can be attributed to the attraction and repulsion of electric charges at the atomic scale.
- Energy has many different forms and must be conserved.

Skills - What will students be able to do?

- Calculate the force, mass, or acceleration of an object given two of these variables.
- Use the momentum equation to show how the the mass or velocity of an object can affect the momentum of an object.
- Use Newton's Universal law of gravity and Coulomb's law to determine the influence of gravity and electric fields respectively.
- Develop a model of the atom to show how electric charges can repel or attract.
- Show how energy is neither lost or gained in a system but transferred by determining the initial and final forms of energy in a conservation of energy problem.

Activities - How will we teach the content and skills?

- Students will learn how mass, acceleration, and force are related using a Phet simulation on Forces and basic motion and through notes on the subject.

- Students will learn how mass and velocity are related in terms of momentum by completing a lab using the the following Phet simulation

- Students will learn the influence of gravity on orbiting bodies in space using this Phet diagram

- Students will work through this lab activity introducing electrostatic charges in matter.

- Students will work through this lab activity looking at the conservation of energy.

Evidence/Assessments - How will we know what students have learned?

- Google forms quiz and solve Newton's second law equation questions.

- Momentum Assessment questions

- Momentum lab activity and questions

- Students will complete the activity questions in the electrostatic charge activity.

- Students will complete assessment on a Skate Park Virtual Phet lab.

- Integrated Science Unit 1 Benchmark

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• Calculate the force, mass, or acceleration of an object given two of these variables using Newton's 2nd Law of motion. • The conservation of momentum • The conservation and transfer of energy into different forms	• Determine both balanced and unbalanced forces acting on an object. • The concept of a conserved system from the unit covering the chemical principle of the conservation of mass. • Determining the forms that energy can take, including chemical energy that the	• Review balanced and unbalanced forces acting on an object and what it means for an object to "accelerate". • Review of the conservation of mass in basic chemistry and how the concept can be applied to the conservation of momentum. • Identify and review the

	body uses for fuel and kinetic and potential energy.	types of energy that exist and how energy can transfer between from potential to kinetic.

Key Resources

Glencoe Physical Science

Phet Simulations

Google Classroom

Brain Pop

21st Century Life and Careers

WRK.9.2.12.CAP.3	Investigate how continuing education contributes to one's career and personal growth.
WRK.9.2.12.CAP.4	Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
WRK.9.2.12.CAP.5	Assess and modify a personal plan to support current interests and post-secondary plans.

Career Readiness, Life Literacies, & Key Skills

TECH.9.4.12.CT.4	Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
TECH.9.4.12.TL.2	Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
TECH.9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
TECH.9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
TECH.9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8).
TECH.9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).

Interdisciplinary Connections/Companion Standards

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
LA.RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LA.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.