Science- Grade 6

Unit 1 Title: Rocket Sled- Motions in Systems

Unit Overview

This unit focuses on how forces affect motion and the energy objects have because of their motion. It begins with students asking questions about the motion of a rocket sled snow plow as it accelerates and then crashes into a car. Students will observe forces acting on the car and will consider how Newton's Third Law helps to explain the motion of a rocket sled. Students take measurements of the motion of a rocket balloon car to determine the effect of mass and force on its motion. Students study the effect that crashes have on the objects involved in the collision by observing changes to a piece of clay that is incorporated into the colliding sled and car to investigate how changes to mass and changes to velocity affect the damage in the collision. By studying and applying Newton's laws of motion and force, students will be able to make connections to the fact that the more force there is, the faster and farther an object will move.

PA Academic Standards Science

- 3.2.6.A3 Explain and give examples of how mass is conserved in a closed system.
- 3.2.6.B1 Explain how changes in motion require a force.
- 3.2.6.B2 Describe energy as a property of objects associated with heat, light, electricity, magnetism, mechanical motion, and sound. Differentiate between potential and kinetic energy.
- 3.4.6.E3 Investigate that power is the rate at which energy is converted from one form to another or transferred from one place to another.

NGSS Disciplinary Core Ideas

- PS2.A.1 For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- PS2.A.2 The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- PS2.A.3 All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.
- PS3.A.1 Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- PS3.B.1 When the motion of energy of an object changes, there is inevitably some other change in energy at the same time.
- ETS1.B.1 A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- ETS1.B.2 There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.

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ETS1.C.2 The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Core Standards Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6-8.7 Integrate quantitative information expressed in words in a text with a version of that information expressed visually (i.e. graph or table).

Content

- Forces & Motion
  - Newton's Laws of Motion
  - Relationship between force and motion
- Conservation of Energy and Energy Transfer
  - Stored (potential) energy
  - Relative positions
  - When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
- Developing Possible Design Solutions
  - Design solution to perform a specific task
  - Re-engineer design solutions
  - Implement findings to optimize solutions

Skills

- Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Inquiry Questions (*include factual, conceptual, debatable)*

- **Factual**
  What is the difference between balanced and unbalanced forces? What affects the speed of a moving object? What causes an object to move at fast speeds? What relationship does mass have in force and motion?
- **Conceptual**

How are force and motion related? How does force play a role in conservation of energy? How do you model the interaction of force or motion in a system where two objects exert forces on each other?

- **Debatable**
  To what extent can scientific principles be manipulated to account for changes to the force acting upon an object?

Resources

"Unit 1: Rocket Sled." *Discovery Education Middle School Science Techbook*, Discovery Education, https://app.discoveryeducation.com/learn/techbook/units/20b81086-5598-427a-9826-9ae3a0c40d8c.

Unit 2 Title: Forces, fields, and energy.

Unit Overview

This unit uses the mystery of a levitating tinsel orb to drive students to explore forces, fields, and energy. Students observe a demonstration of the levitating orb experiment and ask questions about the forces that are acting on the orb as it remains suspended in the air above a pipe after it is scrubbed with a fuzzy cloth. Students consider different physical forces—the gravitational force, the magnetic force, and the electric force—and evaluate which of them might be involved in the levitating behavior of the tinsel orb. Students proceed to learn about the types of forces, performing a variety of hands-on experiments to investigate how gravity, magnetism, and static electricity work in nature. They apply what they learn about each force to the levitating-orb system, revising their model and constructing explanations as they gather evidence to deepen their understanding of the phenomenon. After they evaluate each force type, students explore how force fields store energy, which causes the orb to move, fall, or levitate depending on changes in the location of the charged pipe. By studying and applying the laws of gravity, magnetism, and static electricity, students will be able to identify the cause and effect relationships relating to how electric forces act and interact with different objects.

PA Academic Standards Science

3.2.6.B1 Explain how changes in motion require a force.
3.2.6.B2 Describe energy as a property of objects associated with heat, light, electricity, magnetism, mechanical motion, and sound.Differentiate between potential and kinetic energy.
3.2.6.B4 Describe how electric current produces magnetic forces and how moving magnets produce electric current.
3.3.6.B1 Recognize the role of gravity as a force that pulls all things on or near the earth toward the center of the earth and in the formation of the solar system and the motions of objects in the solar system.
3.2.6.B3 Give examples of how heat moves in predictable ways, normally flowing from warmer objects to cooler ones until they reach the same temperature. Explain the effect of heat on particle motion by describing what happens to particles during a phase change.
3.4.6.D1 Apply a design process to solve problems beyond the laboratory classroom.
3.4.6.C2 Show how models are used to communicate and test design ideas and processes.

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NGSS Disciplinary Core Ideas

PS2.B.1 Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

PS2.B.2 Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the Sun.

PS2.B.3 Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively).

PS3.A.2 A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C.1 When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

ETS1.B.3 Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

Core Standards Literacy

L.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Content

- Types of Interactions
    - Gravitational
    - Electric and magnetic
    - Charged Objects
- Definitions of Energy
    - Kinetic and potential
- Relationship Between Energy and Forces

Skills

- Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
- Construct and present arguments using evidence and visual displays to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- Conduct research and analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

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Inquiry Questions (*include factual, conceptual, debatable)*

- **Factual**
  How does gravity work? What causes Earth to have gravity? What is electric charge? Can all objects become electrically charged? How does magnetism work?
- **Conceptual**
  What role does gravity play in systems? What role does static charge play in directing behavior and movement of objects? What is the relationship between energy and forces? What forces can cause an object to appear to "float or levitate"?
- **Debatable**
  To what extent can forces and energy transfer be used to solve practical problems?

Resources

"Unit 2: Rocket Sled." *Discovery Education Middle School Science Techbook*, Discovery Education, https://app.discoveryeducation.com/learn/techbook/units/7df10e3d-c6ef-403e-a420-8781fbce4764c.

Unit 3 Title: The Behavior of Water | Water Cycle

Unit Overview

In this unit, students will investigate the concepts of the kinetic molecular theory through a study of changes of state as it applies to a water build up on air conditioner coils that ultimately freezes. The unit starts with students asking questions about why water drips from an air conditioner unit. Students will be asked to consider the inner workings of an air conditioner unit to illustrate how the coolant in the unit actually cools the room in which the air conditioner is placed. Students will use observation and investigation skills to help explain the behavior of the water collecting on the air conditioner using the kinetic molecular theory and the water cycle. Students are then challenged to create a simple model of the water cycle to illustrate their understanding of the kinetic molecular theory and apply this knowledge to be able to answer the driving question about why air conditioners drip water. After learning about properties of matter and types of energy, students will understand that there are changes in particle motion, temperature, and state of matter as a result of a change in energy.

PA Academic Standards Science

3.2.6.B2 Describe energy as a property of objects associated with heat, light, electricity, magnetism, mechanical motion, and sound. Differentiate between potential and kinetic energy.

3.2.6.B3 Give examples of how heat moves in predictable ways, normally flowing from warmer objects to cooler ones until they reach the same temperature. Explain the effect of heat on particle motion by describing what happens to particles during a phase change.

3.2.6.B6 Demonstrate that heat moves in predictable ways from warmer objects to cooler ones.

3.2.6.A1 Distinguish the differences in properties of solids, liquids, and gases. Differentiate between volume and mass. Investigate that equal volumes of different substances usually have different masses.

3.3.6.A4 Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.

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NGSS Disciplinary Core Ideas

PS1.A.3 Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

PS1.A.4 In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

PS1.A.6 The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

PS3.A.3 The term heat as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.

PS3.B.2 The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

PS3.B.3 Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ETS1.A The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful.

ETS1.B There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.

Core Standards Literacy

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6-8.7 Write arguments focused on discipline-specific content.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Content

- Structure and Properties of Matter
  - Gases and liquids
  - Molecules and atoms
  - Changes of state
- Definitions of Energy
  - Thermal energy
  - Kinetic energy
  - Potential energy
- Conservation of Energy and Energy Transfer
  - Law of the Conservation of Energy
  - Determining the amount of energy transferred

Skills

- Construct an explanation of changes of state in terms of heat and thermal energy.

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- Develop a model to explain how temperature changes affect the behavior of water molecules in the air
- Carry out an investigation to collect data and analyze the results to explain what is happening on a molecular level when water is heated to 100 degrees Celsius.
- Construct an explanation of how water gets into the air using the concepts of kinetic and potential energy.
- Plan and conduct an investigation that produces data to show the cause-and-effect relationships to explain variables that affect the rate of evaporation.
- Apply scientific ideas to revise the air conditioner model to describe changes in particle motion and temperature when thermal energy is added.
- Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
- Evaluate multiple design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Inquiry Questions (*include factual, conceptual, debatable)*

- **Factual**
  Where does water come from? What is the relationship between temperature and movement of particles? How does a solid become a liquid? How does a liquid become a gas? What is the difference between thermal, potential, and kinetic energy? What are factors that are responsible for a change of state to matter?
- **Conceptual**
  How are the processes of condensation, evaporation, solidification, and melting related? What is the role of energy in changing the state of a substance? What happens during energy transfer? Why does adding heat during a change of state not cause an increase in temperature? Why is the temperature not decreasing during a change of state?
- **Debatable**
  Should humans artificially modify the environment and/or other factors to control energy transfer?

Resources

"Unit 3: Air Conditioner." *Discovery Education Middle School Science Techbook*, Discovery Education, https://app.discoveryeducation.com/learn/techbook/units/c9401c17-1bea-4f45-be1b-b89a8c50a07c.

Unit 4 Title: Earth-moon-sun system

Unit Overview

This unit on the changing appearance of the moon begins with students starting to understand that there are many patterns in nature that we can observe, such as the changing appearances of the moon. Then students

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develop their understanding of how the motions within the Earth-moon-sun system create the predictable pattern of the phases of the moon. Students then develop a model of the Earth-moon-sun system to describe how the alignment within the Earth-moon-sun system causes lunar eclipses followed by refining their model to also account for solar eclipses. Students then use data to refine their models to include how the orientation of the moon's orbit causes lunar and solar eclipses to not occur monthly and why we can see total lunar eclipses from a larger area than solar eclipses. Students expand on their ideas of the Earth-moon-sun system and begin to apply them to larger systems including the solar system and galaxy.

PA Academic Standards Science

3.3.6.A1 Recognize and interpret various mapping representations of Earth's common features.

3.3.6.B1 Compare and contrast the size, composition, and surface features of the planets that comprise the solar system as well as the objects orbiting them. Recognize the role of gravity as a force that pulls all things on or near the earth toward the center of the earth and in the formation of the solar system and the motions of objects in the solar system. Explain why the planets orbit the sun in nearly circular paths. Describe how the planets change their position relative to the background of the stars Explain how the tilt of the earth and its revolution around the sun cause an uneven heating of the earth which in turn causes the seasons and weather patterns.

3.3.6.B2 Use models to demonstrate that the phases of the moon are a result of its orbit around Earth.

NGSS Disciplinary Core Ideas

ESS1.A.1 Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models.

ESS1.A.2 Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B.1 The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them.

ESS1.B.2 The model of the solar system can explain eclipses of the Sun and the Moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the Sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

ESS1.B.3 The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Core Standards Literacy

CC.8.6.6-8.G Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Content

- Moon's Changing Shape
  - Patterns of the apparent motion of the Sun, the Moon, and stars
- Earth, Sun, Moon System
  - Lunar Eclipses
- Disappearing Sun
  - Solar Eclipses
- Objects in the Night Sky
  - The solar system

- Gravitational force
- Movement of the objects and seasons

Skills

- Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- Analyze and interpret data to determine scale properties of objects in the solar system.
- Ask questions that arise from careful observation to figure out why the moon always seems to have a different appearance.
- Investigate and describe how the alignment of the objects in the sky, the effects of gravity, and the size of the object determine the patterns we can observe in the night sky

Inquiry Questions (*include factual, conceptual, debatable)*

- **Factual**
  Why is the moon in different parts of the sky on different nights? What causes the phases of the moon? Is the moon's changing appearance the same for everyone on Earth? How does Earth moving around the sun change the pattern of the moon's changing appearance? When do lunar and solar eclipses take place? Why does the moon appear reddish-orange during a lunar eclipse? How far away are the other planets and stars?
- **Conceptual**
  What impacts the patterns in the appearance of the moon? Can other objects in the solar system change patterns? Why are there different types of eclipses? What impacts what we see during an eclipse? How do we know so much about space that we cannot see? How does the size of objects determine the other objects they attract due to gravity? Does the sun affect Earth in a similar way to how Earth affects the moon?
- **Debatable**
  How are humans able to determine the patterns of various objects in the night sky? How does the alignment of the objects, the effects of gravity, and the size of the object determine the patterns we can observe in the night sky?

Resources

"Unit 4: Ever-Changing Moon." *Discovery Education Middle School Science Techbook*, Discovery Education, https://app.discoveryeducation.com/learn/techbook/units/9f9850b6-e298-44c8-a1bb-f20259e2187d.

Unit 5 Title: Healing Cut: Cells & Systems of Living Things

Unit Overview

This unit on cells and body systems begins with students asking questions about how wounds heal. Students compare the ability of living and nonliving things to heal and develop a model to explain healing based on the existence of different types of cells. Realizing that healing requires healthy cells to divide, students search for information on conditions needed for cells to stay healthy and divide. Returning to the issue of the ability of

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living things to heal, students examine the structure of plant cells and the repair of injury in plants. Their study of plants leads students to question how the parts of the body are connected. Students investigate connections between cells, tissues, and systems in an effort to understand how the body is connected and how injury healing is dependent on this connection. The interrelatedness of body parts leads students to wonder how their brain knows they are injured and determines their actions. Students investigate the transmission of information from the senses to the brain and the brain's responding signals that control actions and memories. Students are then challenged to apply their understanding of the relationships between cells, tissues, and systems and how they function to explain a novel event.

PA Academic Standards Science

3.1.6.A1 Describe the similarities and differences of major physical characteristics in plants, animals, fungi, protists, and bacteria.

3.1.6.A2 Describe how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within a food chain from producers (plants) to consumers to decomposers.

3.1.6.A4 Recognize that all organisms are composed of cells and that many organisms are unicellular and must carry out all life functions in one cell.

3.1.6.A5 Describe basic structures that plants and animals have that contribute to their ability to make or find food and reproduce.

3.1.6.A6 Identify examples of unicellular and multicellular organisms.

3.1.6.A8 Explain why the details of most cells are visible only through a microscope.

3.1.6.C1 Differentiate between instinctive and learned animal behaviors that relate to survival.

3.2.6.A5 Identify characteristic properties of matter that can be used to separate one substance from the others.Investigate that materials may be composed of parts too small to be seen without magnification.

NGSS Disciplinary Core Ideas

LS1.A.1 Structure and Function All living things are made up of cells. A cell is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

LS1.A.2 Structure and Function Within cells, special structures are responsible for particular functions. The cell membrane forms the boundary that controls what enters and leaves the cell.

LS1.A.3 Structure and Function In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

LS1.D.1 Information Processing Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Core Standards Literacy

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Content

- Microscopic Structures
    - Unicellular
    - Multicellular
- Healthy Cells

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    - Parts of a cell
    - Multicellular organisms
    - Multiple interacting subsystem
- Plant Repair
    - Changes in wounded plants clarify the process of a healing cut
- How Does it All Connect?
    - Function of cells, tissues and organs
    - Cause and effect relationships in living systems
- To The Brain and Back
    - Sensory receptors and brain processing

Skills

- Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Inquiry Questions (*include factual, conceptual, debatable)*

- **Factual**
  What is telling your mind that you need to fix the cut? What is happening when the cut heals? What specific parts of the body and brain are used in the process of healing? How do cells get energy? What are the different types of cells in plants and animals? How is an organism with only one type of cell different from an organism with many types of cells?
- **Conceptual**
  What happens if part of the cell does not work properly? How do cell structures perform their functions? What happens if one part of a cell is not working, is damaged, or is missing? Why do plant cells have different structures than animal cells?
- **Debatable**
  How can a problem with one of my body systems affect another system?

Resources

"Unit 5: Healing Cut." *Discovery Education Middle School Science Techbook*, Discovery Education, https://app.discoveryeducation.com/learn/techbook/units/6e16eae8-816e-4c0b-9ad8-39278b4e70d9.