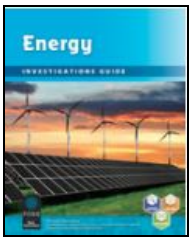
# Investigation 1 - Energy and Circuits




Students investigate the phenomenon of electric current in circuits, the pathways through which electricity flows. They work with a variety of components - D-cells, lightbulbs, motors, switches and wires - and explore conductors and insulators. They explore series and parallel circuits and compare the functioning of the components in each circuit. They formulate and justify their predictions, based on their observations of electricity transferring energy to produce light and motion.

Standard - 4-PS3-2, 4-PS3-4, 3-5 ETS1-1, 3-5 ETS1-2, 3-5 ETS1-3

| **Investigation 1** | **Summary of Lesson** | **Priority** |
|---|---|---|
| Part 1: Lighting a Bulb | Students are introduced to electricity and energy. They discover how to make a complete circuit using a D-cell, wires, and a lightbulb. Upon successfully lighting their bulbs, students discuss the electricity's pathway in the circuit and the function of each of the system's components. They also take a close look at the anatomy of a lightbulb.<br>*Read, "Edison sees the light".*<br>*Activity, "Lighting a Bulb" and "Flow of Electricity".*<br><br>*FQ - What is needed to light a bulb?* | High<br>Introduction to concepts of circuitry and content vocabulary. |
| Part 2: Conductors and Circuits | Students are introduced to a switch and a motor and make a circuit that they can turn on and off. Students use a circuit and a collection of objects to determine which materials can complete the pathway (conductors) and which cannot (insulators). After developing the rule that metals are conductors, students consider foils and use evidence to confirm that foils are indeed metal.<br>*Read, "Energy Sources".*<br><br>*FQ -What materials transfer electricity?* | High<br>This lesson is the introduction for later lessons. |
| Part 3: Series and Parallel Circuits | Students find ways to operate more than one lightbulb in a circuit. They devise a series circuit to operate two bulbs with one D-cell, but the lights are dim. Students learn that they can connect two bulbs in a way that allows others to shine brightly using two cells or a single D-cell. They wire two bulbs in parallel and find that many bulbs can be made to shine brightly on a single D-cell when they are wired in parallel.<br>*Read, "Series and Parallel Circuits".*<br><br>*FQ - How can you light two bulbs brightly with one D-cell?* | High<br>This lesson teaches the differences between parallel and series circuits. |

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| Part 4: Solving the String-of-Lights Problem | Students investigate which type of circuit would be the best design for a string of lights. They analyze the designs and make a recommendation based on their knowledge of circuitry.<br>*Read, " Science Practices", "Engineering Practices", "Thinking Like an Engineer", and "Engineering a Solar Lighting System".*<br><br>*FQ - Which design is better for manufacturing long strings of lights - series or parallel?* | Medium<br>This lesson is a nice example of standard **3-5 ETS1-1,** however, if limited on time, this lesson could be skipped. |
| Assessment | i-Check | |

## Investigation 1 cont. - Energy and Circuits

**4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

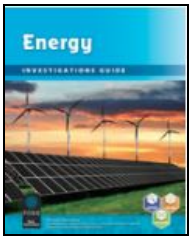
**4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**3-5 ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

**3-5 ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

**3-5 ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

# Investigation 2 - The Force of Magnetism




Students investigate the phenomenon of magnets and their interactions with materials and each other. Students go outdoors to find objects in the environment that are attracted to magnets. They conduct an investigation to determine if like or opposite poles of a magnet attract. They construct a simple compass and use it to detect magnetic effects. They also discover that magnetism can be induced in a piece of iron. They investigate the strength of the force of attraction between two magnets by graphing data to look for patterns of interaction. The first two investigations provide the foundation for students to develop an understanding of electromagnetism in the next investigation.

Standards - 3-PS2-3, 4-PS3-4

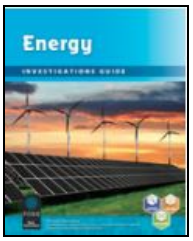
| **Investigation 2** | **Summary of Lesson** | **Priority** |
|---|---|---|
| Part 1: Magnets and Materials | Students discover that iron-containing objects stick to permanent magnets; other objects do not. They generate a rule for magnetic interaction with materials; If a magnet sticks to an object, that object is most likely made of iron or its alloy, steel. Students go outdoors and use their magnets as iron detectors.<br>*Activity, "Virtual Investigation" What Sticks and what Conducts?"*<br>*FQ - What materials stick to magnets?* | High<br>In this lesson, students are learning that objects that contain iron are magnetic.<br><br>**If time is limited, you can always skip the outdoor exploration, or have students conduct this on the way in from recess. |
| Part 2: Magnetic Fields | Students observe that the two sides (poles) of magnets are different, attracting or repelling one another, depending on orientation. Students work with magnets and other objects to discover that magnetism acts through air, most metals, and all nonmetals. They also discover that bringing a magnet close to a piece of iron induces magnetism in the iron. Students learn that these effects are manifestations of the invisible magnetic field that surrounds every magnet.<br>*Read, "When Magnet Meets Magnet".*<br>*Video, "All about Magnets".*<br>*Activity, "Magnetic Poles" and "Magnetic Fields".*<br>*FQ - What happens when two or more magnets interact?*<br>*What happens when a piece of iron comes close to or touches a permanent magnet?* | High<br>Students learn about polarity of magnets, and invisible magnetic forces, strongly meeting standard, **3-PS2-3.** |
| Part 3:Magnetic Force | Students use a balance to measure the force of attraction between magnets. They increase the distance between the magnets and remeasure the force. Students learn that the force of attraction between magnets decreases as the distance between them increases.<br>*Read, "Magnificent Magnetic Models" and "Make a Magnetic Compass".*<br>*FQ - What is the effect on the force of attraction between two magnets as the distance between them changes?* | Medium<br>Although this activity also meets standard **3-PS2-3,** if time is limited, this lesson could be skipped. |
| Assessment | i-Check | |

# Investigation 2 cont. - The Force of Magnetism

**3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

**4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

# Investigation 3 - Electromagnets




Students investigate the phenomenon of electromagnetism. Students learn how to use electricity to make an electromagnet. They explore the variables that influence the strength of the magnetism produced by their electromagnets. Students use all the concepts they have learned to engineer a simple telegraph system and communicate using a click code.

Standards - 3-PS2-3, 4-PS3-2, 4-PS3-4, 4-PS4-3, 3-5 ETS1-3

| **Investigation 3** | **Summary of Lesson** | **Priority** |
|---|---|---|
| Part 1: Building an Electromagnet | Students discover that a steel core becomes a magnet when current flows through an insulated wire wound around the steel core. They find out where to wind the wire on the core to produce the strongest magnet.<br>*Read, "Electricity Creates Magnetism"*<br><br>*FQ - How can you turn a steel rivet into a magnet that turns on and off?* | High<br>Students are learning about energy transfer. |
| Part 2: Changing the Strength | Students experiment to find out how the number of winds of wire affects the strength of magnetism. After collecting data for a 20-wind, 30-wind, and 40-wind electromagnet, students graph the results. They predict the strength of magnetism based on the graph.<br>*Read, "Using Magnetic Fields" and "Electromagnets Everywhere".*<br><br>*FQ - How does the number of winds of wire around a core affect the strength of the magnetism?* | High<br>Students are testing energy transfer and meeting standard **4-PS3-2.** |
| Part 3: Reinventing the Telegraph | Students apply their knowledge of circuitry and electromagnetism to build a telegraph. They invent a code and use their telegraphs to send messages to each other. Finally, they take on the long-distance challenge by wiring two telegraph units together using long wires.<br>*Read, "Morse Gets Clicking".*<br><br>*FQ - How can you reinvent the telegraph using your knowledge of energy and electromagnetism?* | Low<br>Although this activity is of high interest to students, and meets standard **4-PS4-3** and **ETS1-3,** it could be skipped if limited time. |
| Assessment | i-Check | |

# Investigation 3 cont. - Electromagnets

**3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

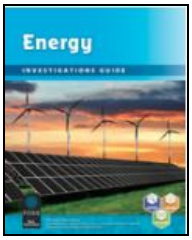
**4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

**4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**4-PS4-3** Generate and compare multiple solutions that use patterns to transfer information.

**ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

# Investigation 4 - Energy Transfer




Students observe the phenomenon of energy transfer that results in heat, light, sound, and motion. Students are introduced to sources of energy and components that store energy (potential energy of position or condition). They conduct structured investigation with steel balls and ramps to discover how the variable of starting position on the ramp affects the speed of the rolling ball. Using controlled experiments involving the transfer of potential energy into kinetic energy, students test the variables of mass and release position to find out how these variables affect energy transfer.

Standards - 4-PS3-1, 4-PS3-2, 4-PS3-3

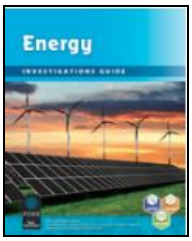
| **Investigation 4** | **Summary of Lesson** | **Priority** |
|---|---|---|
| Part 1: Presence of Energy | Students work in centers to explore evidence of energy when sound, heat, and light are produced, and when objects are in motion.<br>*Read, "Energy".*<br>*FQ - What do we observe that provides evidence that energy is present?* | High<br>This lesson strongly meets standard **4-PS3-2.** |
| Part 2: Rolling Balls Down Slopes | Students roll steel balls of different sizes down ramps and explore the system's variables. They conduct structured investigations to discover how the variables of starting position on the ramp and ball size (mass) affect the speed of a rolling ball.<br>*Read, "What Causes Change of Motion?"*<br>*Video, "Soccer, Ball on Table, and Wagon".*<br>*FQ - How does the starting position affect the speed of a ball rolling down a ramp?* | High<br>This lesson strongly meets standard **4-PS3-3.** |
| Part 3: Collisions | Students place an obstacle (cork) in the pathway of a steel ball rolling down a ramp, forcing them to collide. They investigate the variables that determine how far the cork will move along the runway. Using controlled experiments, students test the variables of mass and starting position to find out how these variables affect energy transfer.<br>*Read, "Bowling", "Force and Energy", and "Potential and Kinetic Energy at Work".*<br>*Video, "All about the Transfer of Energy".*<br>*FQ- What happens when objects collide?* | Low<br>Although this is a nice example of energy transfer, students have been able to see these examples in other lessons. |
| Assessment | | |

**4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.

**4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

**4-PS3-3** Ask questions and predict outcomes about the changes in energy that occur when objects collide..

# Investigation 5 - Waves




Students experience the phenomenon of waves through firsthand experiences using ropes, demonstrations with waves in water, spring toys, and a sound generator. They also use videos, animations, and readings to gather information. Through these experiences, students learn that waves are repeating patterns of motion that transfer energy from place to place. They analyze compression waves (sound waves) to learn the general properties of waves - amplitude, wavelength, and frequency.

Students use mirrors to experience reflecting light. They start by using mirrors outdoors to see objects behind them and to reflect a bright image of the Sun onto walls. In the classroom, they determine that a mirror can be used to reflect light. Students then use flashlights, mirrors, and water to observe light in numerous ways, reinforcing the idea that light can reflect and refract. Students build a conceptual model about how light travels.

Students use light wave energy to design series and parallel solar cell circuits and observe the effect on the speed of a motor. They observe that cells in series make the motor run faster, but cells in parallel do not deliver additional power to the motor. They read about alternative energy sources.

Standards - 4-PS3-2, 4-PS3-4, 4-PS4-1, 4-PS4-2, 4-ESS3-1, 3-5 ETS1-1, 3-5 ETS1-2, 3-5 ETS1-3

| **Investigation 5** | **Summary of Lesson** | **Priority** |
|---|---|---|
| Part 1: Forms of Waves | Students experience waves through firsthand experiences using ropes, demonstrations with waves in water, spring toys, and sound generator. They also use videos, animations, and readings to gather information. Through these experiences, students learn that waves are repeating patterns of motion that transfer energy from place to place. They analyze compression waves (sound waves) to learn the general properties of waves-amplitude, wavelength, and frequency.<br>*Read, "Waves" and "More about Sound".*<br>*Video, "Sound Energy", "Waves", "Real World Science: Sound" and "All about Waves".*<br>*FQ - How are waves involved in energy transfer?* | High<br>Introduction to concepts of waves and wavelengths and content vocabulary. |
| Part 2: Light Travels | Students use mirrors to experience reflecting light. They start by using mirrors outdoors to see objects behind them and to reflect a bright image of the Sun onto walls. In the classroom. They determine that a mirror can be used to reflect light. Students then use flashlights, mirrors, and water to observe light in numerous ways, reinforcing the idea that light can reflect and refract. Students build a conceptual model about how light travels.<br>*Read, " Light Interactions", "Throw a Little Light on Sight", and "More Light on the Subject".*<br>*Video, "All about Light".*<br>*Activity, "Reflected Light" and "Tutorial: Reflection"*<br>*FQ - How does light travel?* | High<br>This lesson strongly meets standard **4-PS4-2.** |

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| Part 3: Engineering with Solar Cells | Students design series and parallel solar cell circuits and observe the effect on the speed of a motor. They observe that cells in series make the motor run fast, but cells in parallel do not deliver additional power to the motor. They read about alternative energy sources.<br>*Read, "Alternative Sources of Electricity" and "Ms. Osgood's Class Report".*<br>*Video, "Wave".*<br>*FQ- How can you make a motor run faster using solar cells?* | Low<br>Although this lesson strongly meets the engineering standards at 3-5 grades, it could be skipped if there is not enough time. |
| Assessment | | |

## Investigation 5 cont. - Waves

**4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

**4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

**4-PS4-2** Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

**4-ESS3-1** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

**3-5 ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

**3-5 ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

**3-5 ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.