



Harnessing Human Energy



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Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.
8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.
9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.
10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.
11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: _____

Date: _____

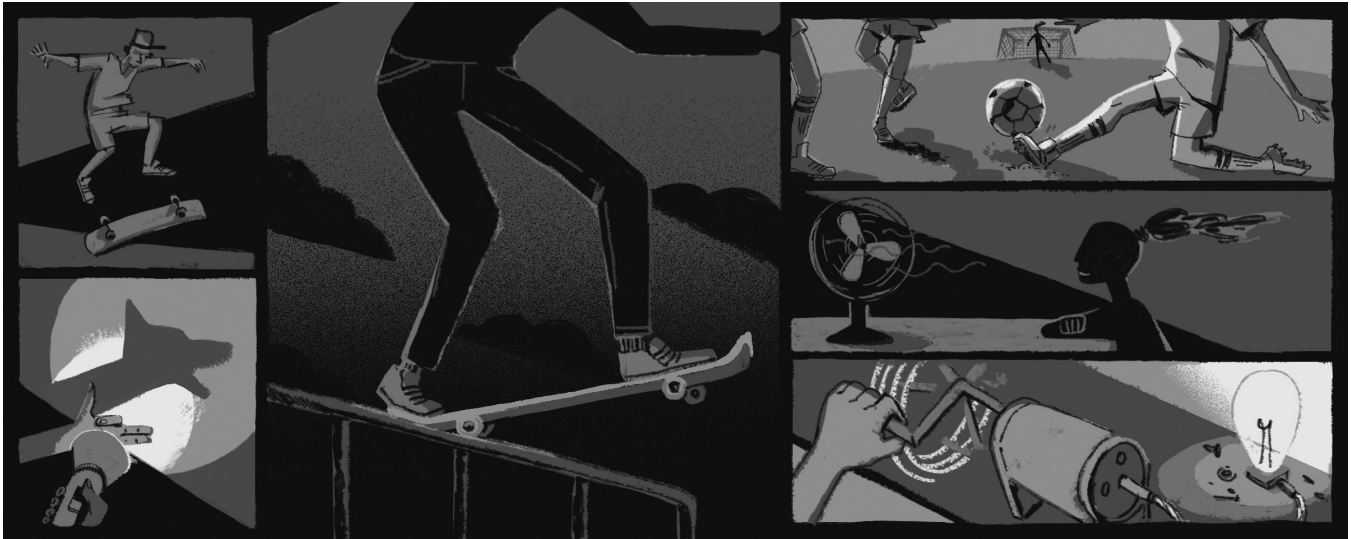
Harnessing Human Energy **Unit Overview**

How is it possible to charge electrical devices when the power is out? This is the question that you and your classmates will investigate in your role as student energy scientists. Your challenge is to design a way for rescue workers to get energy to their electrical devices (flashlights, cell phones, and radios), even when they are on rescue missions, far from electrical outlets. To do this, you'll need to learn about possible sources of energy, including energy stored in the bodies of the rescue workers, and figure out a way to capture that human energy. Scientists and engineers have been inventing new ways to solve everyday energy problems; now you and your classmates will have the opportunity to contribute your own valuable ideas.

Chapter 1: What Is Energy?

Chapter Overview

Welcome to the Energy Research Lab! As a student energy scientist, you will learn about what energy is and how you know whether an object has energy. Answering these questions will help you understand why energy matters to a rescue team.



Name: _____

Date: _____

Lesson 1.1: Welcome to the Energy Research Lab

Welcome to your role as a student energy scientist at the Energy Research Lab. A rescue team needs your help: the team needs to use small electrical devices, such as flashlights, on rescue missions, but these devices often run out of energy. The rescue team needs to find a way to get energy to their flashlights and other devices even when the power is out. Today you will explore what energy is, and you will use a digital simulation to find ways to make a light shine. This will help you begin to solve the rescue team's problem.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Vocabulary

- energy
- system

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: What Has Energy?
- *Harnessing Human Energy* Simulation

Name: _____

Date: _____

What Has Energy?

1. Launch the *Harnessing Human Energy* Sorting Tool activity: What Has Energy? and follow the instructions below.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

Goal: Decide whether each object does or does not have energy.

Do:

- Drag objects that you think have energy to the Things That Have Energy bin.
- Drag objects that you think do not have energy to the Things That Don't Have Energy bin.
- Leave objects you are not sure about in the toolbar.

Tips:

- Make sure to read the object descriptions.
- Scroll down on the toolbar to make sure you see all of the objects.
- You can overlap objects if you need to.
- Remember to press HAND IN when you are done.

Name: _____

Date: _____

Using a Simulation to Make the Light Shine

Part 1

Explore the *Harnessing Human Energy* Simulation.

- What can you do in the Sim? What do you observe?
- Share what you notice with a partner.
- Later, your teacher will give you a mission to accomplish in the Sim.

Part 2

1. Return to the Simulation and build a system that makes a light shine.
2. After you build a system that makes a light shine, discuss the question below with your partner, and then record your thinking.

Based on your ideas about energy, where do you see examples of energy in the system you built?

Name: _____

Date: _____

Homework: Reflecting on Energy

1. Do you think a moving skateboard has energy? Why or why not?

2. Do you think people used energy before modern times? Why or why not?

3. How well do you think you understand energy? Use the scale below to rate how well you understand energy (check one).

- 1: I don't understand energy at all.
- 2: I know just a little about energy.
- 3: I know a fair amount about energy, but there is a lot I don't know.
- 4: I know a lot about energy.
- 5: I understand everything there is to know about energy!

Lesson 1.2: Investigating Energy Claims

Today you will learn how to tell if an object has energy. To do this, you will build systems that make a fan spin, and you'll think carefully about whether the systems have energy. You will also learn how scientists make arguments, and you'll use the evidence you gathered about energy in systems to support a claim just as a scientist would.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Vocabulary

- claim
- energy
- evidence
- reasoning
- scientific argument
- system

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: What Has Energy?

Name: _____

Date: _____

Warm-Up



Dear student energy scientists,

People use the word *energy* to mean a lot of different things. In an everyday sense, *energy* can mean excitement or having what it takes to run a marathon. In a scientific sense, *energy* has a specific meaning:

Energy is the ability to make things move or change.

Please use this scientific definition of *energy* to revise your thinking about what has energy.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. Return to the Sorting Tool activity: What Has Energy? from the previous lesson and revise your work.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____
3. In the space below, explain what you revised, or why you kept it the same.

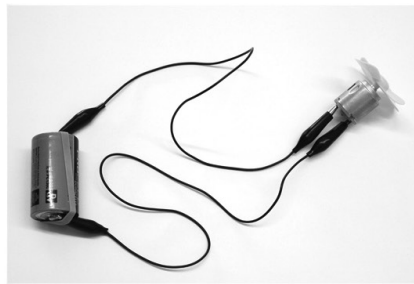
Investigating Energy Systems

Part 1: Do *All* the Systems Have Energy?

- Use the materials to build each system with your group.
- After you build each system, use the Reasoning Tool on the next page to record evidence about whether or not each system has energy.
- Remember that energy is the ability to make things move or change.



Hand-Crank Generator System



Battery System



Solar Cell System

Investigating Energy Systems (continued)

Part 2: Reasoning Tool

Possible subclaims:

- The Battery System does have energy.
or
The Battery System does not have energy.
- The Hand Crank Generator System does have energy.
or
The Hand Crank Generator System does not have energy.
- The Solar Cell System does have energy.
or
The Solar Cell System does not have energy.

Evidence (observations about whether the system does or does not have energy)	This matters because . . . (How does this evidence support the subclaim?)	Therefore, . . . (subclaim)

Name: _____

Date: _____

Homework: Do These Objects Have Energy?

- Use what you have learned so far about energy to decide whether each of the objects listed below has energy or not.
- Explain your evidence for why you think each object does or doesn't have energy.

1. Food (check one)

has energy

does not have energy

What is your evidence for why you think food has energy or does not have energy?

2. Soccer ball flying through the air (check one)

has energy

does not have energy

What is your evidence for why you think this object has energy or does not have energy?

Name: _____

Date: _____

Homework: Do These Objects Have Energy? (continued)

3. Soccer ball not moving (check one)

has energy

does not have energy

What is your evidence for why you think this object has energy or does not have energy?

4. Fan spinning (check one)

has energy

does not have energy

What is your evidence for why you think this object has energy or does not have energy?

5. Fan not spinning (check one)

has energy

does not have energy

What is your evidence for why you think this object has energy or does not have energy?

Name: _____

Date: _____

Lesson 1.3: Identifying Kinetic Energy and Potential Energy

Welcome back to the Energy Research Lab! In today's lesson, you will continue your research on energy, focusing on how to recognize when things have energy. You will learn about different types of energy today—first through the use of the Sorting Tool, and then through a demonstration by your teacher.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Key Concept

- Whenever something moves or changes, it is because of energy.

Vocabulary

- energy
- evidence
- kinetic energy
- potential energy

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: Evidence of Energy

Name: _____

Date: _____

Warm-Up

The lead energy scientist has forwarded you an email from an Energy Research Lab client. Read the email and decide how you would respond to the client.



Dear student energy scientists,

Now that you have been learning about energy, I would like your help responding to some questions we receive here at the Energy Research Lab. Please see the email I've included below.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

Email from client:

Dear Energy Research Lab,
My friend drives around in her electric car, and she has to charge the car's batteries every night. However, I never need to plug in my bike! Therefore, I think I can get from place to place without using energy at all.
What do you think? **Is riding a bike a way to travel that doesn't use energy?**

Sincerely,
Sasha (Energy Research Lab client)

1. Which of the following statements would you include in your response to the client? (check one)

- Riding a bike doesn't use energy.
- Riding a bike does use energy.
- I'm not sure if riding a bike uses energy or not.

2. Explain the statement you selected in the space below.

Name: _____

Date: _____

Evidence of Energy

1. Launch the Sorting Tool activity: Evidence of Energy and follow the instructions below. Talk to a partner about your ideas as you work.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

Goal: Look at each object and decide whether you can see evidence of energy.

Do:

- Think about the definition of *energy* as you look at each object. Do you see evidence of energy?
- If you can't see evidence of energy, drag the object to the bin on the left.
- If you can see evidence of energy, drag the object to the bin on the right.
- Leave objects you are not sure about in the toolbar.

Tips:

- Scroll down on the toolbar to make sure you see all of the objects.
- Remember that energy is the ability to make things move or change.

Name: _____

Date: _____

Kinetic Energy and Potential Energy Demonstration

Before your teacher begins the demonstration, answer the following questions by selecting the option that best completes each sentence.

1. A wind-up toy that is not wound up. . . (check one)

- does not have energy.
- has kinetic energy.
- has potential energy.
- has both kinetic and potential energy.

2. A wind-up toy that is wound up but not moving. . . (check one)

- does not have energy.
- has kinetic energy.
- has potential energy.
- has both kinetic and potential energy.

3. A wind-up toy that is wound up and moving. . . (check one)

- does not have energy.
- has kinetic energy.
- has potential energy.
- has both kinetic and potential energy.

Name: _____

Date: _____

Reflection

How do you know whether an object has potential energy?

- Circle one object from the choices below that you think has potential energy.
- Explain why you think the object you selected has potential energy.

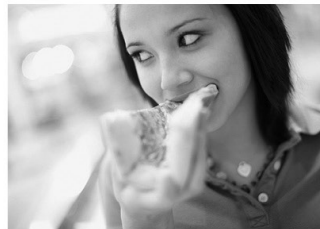
skateboard at top of ramp



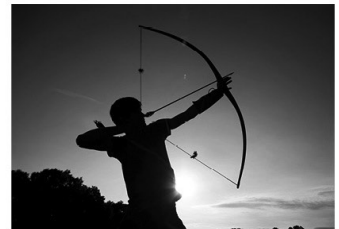
charged battery



food



stretched bow and arrow



Why do you think this object has potential energy?

Name: _____

Date: _____

Homework: Energy and the Rescue Team

You have been investigating why energy matters to the rescue team, and now you've learned about two different categories of energy.

1. What is one way that kinetic energy might be involved in rescue team missions?

2. What is one way that potential energy might be involved in rescue team missions?

Lesson 1.4: “Energy Inventions”

Scientists around the world are working to solve the world’s energy problems in creative ways. Some of these solutions were designed by people not much older than you. Today you’ll read an article about some of these energy inventions and the scientists who designed them. You will practice reading like a scientist: carefully and actively, making sure that you understand the text and images. You will record your questions and ideas as you read, and you’ll have a chance to discuss your thoughts about the article with others.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.

Vocabulary

- energy
- kinetic energy
- potential energy

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: Kinetic or Potential Energy?

Name: _____

Date: _____

Warm-Up

1. Launch the Sorting Tool activity: Kinetic or Potential Energy? and follow the instructions below.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

Goal: Decide whether each object has kinetic energy or potential energy.

Do:

- If you think an object has potential energy, drag it to the Potential Energy bin.
- If you think an object has kinetic energy, drag it to the Kinetic Energy bin.

Tips:

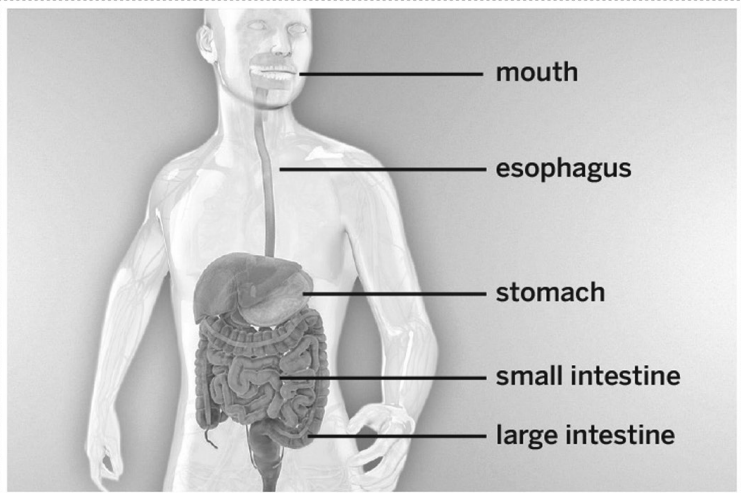
- Kinetic energy is the energy that an object has because it is moving.
- Potential energy is the energy that is stored in an object or system.

Introducing Active Reading

- What do you notice about this student's annotations?
- How do you know that she was thinking carefully while reading and trying to understand the article?

Scientist Profile

Certain combinations of bacteria, fungi, and other microbes in the human microbiome can cause health problems, but other combinations may be able to keep people healthy. By identifying which combinations make people sick, scientists might be able to tell what changes to the microbiome could treat those illnesses or prevent them from happening at all. Someday, Lynch believes that doctors will be able to tell patients exactly what combinations of bacteria, fungi, and other microbes they need in their systems to stay healthy.



mouth
esophagus
stomach
small intestine
large intestine

Do different people have different combinations? Why wouldn't they be all the same?
Note added three days ago EDIT

Diagram Question: Are microorganisms all over the body or just in the digestive system?
Note edited today EDIT

Diagram Question: Is the digestive system really red?
Note edited today EDIT

Many of the microbes Dr. Susan Lynch studies are found in the human digestive system. (© 2015 The Regents of the University of California)

Name: _____

Date: _____

Reading “Energy Inventions”

1. Read and annotate the article “Energy Inventions.”
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- Never
- Almost never
- Sometimes
- Frequently/often
- All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Lesson 2.1: Investigating Claims About How Objects Get Energy

The work you've done so far as a student energy scientist has helped you build an understanding of what energy is, and why it matters to the rescue team. You know that the rescue team needs energy to operate electrical devices, but how do devices and other objects get energy? Today you will gather evidence from the Simulation to help answer this question.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- energy
- potential energy
- evidence
- system
- kinetic energy
- transfer

Digital Tools

- *Harnessing Human Energy* Simulation

Name: _____

Date: _____

Warm-Up



Dear student energy scientists,

Rescue workers need to have working equipment, such as flashlights, at all times. But they can't always just charge their equipment by plugging it in. As student energy scientists, your assignment is to make sure the rescue team's equipment works in any emergency situation. To prepare to help the rescue team, reflect on these questions and record your ideas.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. What types of emergency situations could rescue workers be in that would make it difficult for them to get energy to their electrical devices?

2. What's one idea you have about how rescue workers can get energy to their electrical devices in these situations?

Name: _____

Date: _____

Investigating How Objects Get Energy

How do objects get energy?

- With your partner, decide which claim you will investigate in the Simulation, and select it below.
- Talk to your partner about how you plan to get evidence for or against your claim in the Simulation.
- Use the Reasoning Tool below to record your evidence and explain how the evidence supports or goes against the claim you selected.

The claim we are investigating is (check one)

- Claim 1:** Objects can make their own energy.
- Claim 2:** Objects get energy from other objects that have energy.
- Claim 3:** Only living things have energy.

Reasoning Tool

Evidence (observations from the Simulation)	This matters because . . . (How does this evidence support or go against the claim)	Therefore, . . . (the claim that the evidence supports or goes against) is/is not supported.

Name: _____ Date: _____

Investigating How Objects Get Energy (continued)

Describe the energy system you built in the Sim that provided evidence for or against your claim:

Name: _____

Date: _____

Homework: Where Does Energy Come From?

- Use the Simulation to build two *different* systems that can launch a ball.
- Describe each system you built.
- Answer the question about each system.

System 1 description:

In your first system, where did the ball get the energy that it needed in order to move?

System 2 description:

In your second system, where did the ball get the energy that it needed in order to move?

Lesson 2.2: Evaluating Energy Sources

Does everything have energy? And where does it come from anyway? Today you will revisit the “Energy Inventions” article to get more evidence about how objects get energy. You will also learn about and discuss many different energy sources and decide which energy sources are the best and worst options for the rescue team.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

Digital Tools

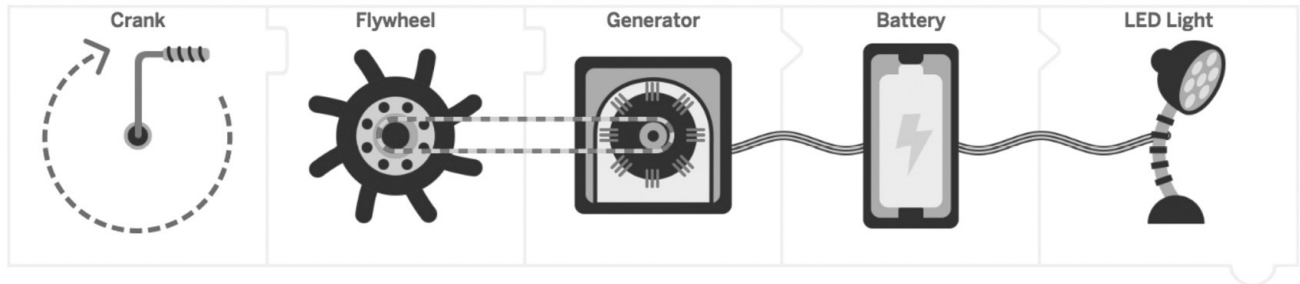
- *Harnessing Human Energy* Sorting Tool activities: Energy from the Sun, Energy from Gasoline, and Energy from Food
- *Harnessing Human Energy* Simulation

Name: _____

Date: _____

Warm-Up

It's important for energy scientists to be able to understand and describe how energy systems work. Look closely at the energy system below and answer the questions.



1. On the lines below, write where each object gets its energy from: the flywheel, the person turning the crank, the battery, or the generator.
 - The light gets its energy from the _____.
 - The battery gets its energy from the _____.
 - The generator gets its energy from the _____.
 - The flywheel gets its energy from the _____.
2. Someone needs to turn the crank to make the flywheel spin. Is this person creating energy? If not, where do you think the person's energy comes from?

Name: _____

Date: _____

Second Read of “Energy Inventions”

Reread the last two paragraphs of the “Energy Inventions” article and highlight evidence that supports or goes against the claims:

- **Claim 1:** Objects can make their own energy.
- **Claim 2:** Objects get energy from other objects that have energy.

Which claim do you think is most convincing based on the evidence you have gathered so far?
(check one)

Claim 1

Claim 2

Name: _____

Date: _____

Evaluating Energy Sources

- Read each Energy Source Card carefully and discuss your questions and ideas about each energy source with your partner.
- Next, arrange the cards in order of best to worst energy source options for the rescue team. Place the cards in a line with the best option on the left and the worst option on the right.
- When you are finished sorting the cards on your desk, answer the questions below.

Energy Sources

nuclear power plant

wind turbine

combustion engine

human-powered generator

hydroelectric power plant

fuel-burning power plant

solar cell

1. Which energy source did you rank as the best option for the rescue team?

Why?

2. Which energy source did you rank as the worst option for the rescue team?

Why?

Name: _____

Date: _____

Homework: Practice with Energy Transfer Diagrams

Energy from the Sun

1. Launch the Sorting Tool activity: Energy from the Sun, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from the sun can be used to make a flashlight shine.

Do:

- Drag the battery and the sun shining on a solar cell to the correct bins.
- Add more objects and arrows to show how energy from the sun can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Energy from Gasoline

1. Launch the Sorting Tool activity: Energy from Gasoline, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from gasoline can be used to make a flashlight shine.

Do:

- Drag the battery and gasoline to the correct bins.
- Add more objects and arrows to show how energy from gasoline can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Name: _____

Date: _____

Homework: Practice with Energy Transfer Diagrams (continued)

Energy from Food

1. Launch the Sorting Tool activity: Energy from Food, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from food can be used to make a flashlight shine.

Do:

- Drag the battery and food to the correct bins.
- Add more objects and arrows to show how energy from food can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Name: _____

Date: _____

Homework: “How We Store Energy”

In this lesson, you evaluated different energy sources, including renewable energy sources such as solar and wind power. One of the big challenges humans face is how to store energy. To learn more about this challenge, read and annotate the “How We Store Energy” article. Then, answer the questions below.

1. How have batteries gotten better over time?

2. Why is it important for scientists to find better ways to store solar and wind energy?

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Lesson 2.3: Writing Scientific Arguments

The lead energy scientist at the Energy Research Lab is eagerly awaiting your response on how you can solve the rescue team's energy problem. Today you will decide on the best energy source for the rescue team. Once this decision is made, you will work with some of your fellow student energy scientists to develop a detailed explanation of how the rescue workers can use this energy source to get energy to the batteries in their flashlights during rescue missions.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- claim
- convert
- energy
- evidence
- generator
- kinetic energy
- potential energy
- reasoning
- system
- transfer

Key Concepts

- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Warm-Up



One of the rescue workers has a special flashlight; it has a crank, and the light shines when the crank is turned. Since the rescue worker has never had to replace the batteries or plug in the flashlight, she thinks this flashlight works without an energy source.

Do you agree or disagree?

- I think the flashlight **does** work without an energy source.
- I think the flashlight **does not** work without an energy source.

I think this because . . .

Name: _____

Date: _____

Word Relationships

1. With a partner, use the words on the Word Relationships Cards to create sentences that answer the Chapter 2 Question: *How can the rescue workers get energy to the batteries in their equipment during rescue missions?*
2. Use at least two words from the Word Relationships Cards in each sentence. You don't have to use all the words.
3. There are many different ways to answer the Chapter 2 Question, so try to create as many sentences as you can. You can also use multiple sentences to express your ideas.
4. When you have created your sentences, join another pair of students and share your responses

Word Bank

energy	convert	transfer
potential energy	kinetic energy	

Writing a Scientific Argument

Part 1: Message from the Lead Energy Scientist

Dear student energy scientists,

The rescue team needs to be sure they do not run out of energy in emergency situations. They are choosing between these two energy sources for the batteries in their equipment—the sun (solar cells) or human-powered generators. Please write an argument that will convince the rescue workers which energy source is the best choice for solving this energy problem.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

ERL Energy
Research
Lab



Part 2: Claims and Evidence

Claim 1: The sun (solar cells) is the best energy source for the rescue team.

Claim 2: Human-powered generators are the best energy source for the rescue team.

Evidence 1: Solar cells transfer energy from the sun to a battery.

Evidence 2: Human-powered generators can be used to transfer energy any time someone is there to turn the crank.

Evidence 3: Solar cells only transfer energy when the sun is shining.

Evidence 4: Rescue missions take place both in the daytime and at night, as well as in many different environments.

Evidence 5: Potential energy stored in a battery can be converted to another form of energy at a later time.

Evidence 6: Human-powered generators transfer energy to a battery when a person turns a hand crank.

After reviewing all the evidence, this is the energy source that is best supported for meeting the rescue team's energy needs: (check one)

Claim 1: The sun (solar cells) is the best energy source for the rescue team.

Claim 2: Human-powered generators are the best energy source for the rescue team.

Name: _____

Date: _____

Homework: Reading About Hand-Crank Flashlights



Dear student energy scientists,

To help you design a system that solves the rescue team's problem, I would like you to learn about some human-powered devices that already exist. I hope learning about these devices will give you ideas that will help you design an original solution to the rescue team's problem.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. Read and annotate the "Hand-Crank Flashlight" article. The first time you read, record your questions and connections.
2. Reread the "Hand-Crank Flashlight" article. While reading the article a second time, make highlights and add annotations that help you answer the question: *How does the hand-crank get energy to a battery?*

Chapter 3: Designing an Energy Solution Chapter Summary

All over the world, energy scientists and engineers are inventing ways to capture energy from the human body’s motion to charge electrical devices. In Chapter 3, you will learn about some of these inventions, and you will design a system that captures energy from rescue workers’ motion to charge the batteries in their electrical devices.



Lesson 3.1: Reading About Energy Systems

Based on your research and the research of other student energy scientists, the rescue workers have decided that they would like to use kinetic energy from their bodies to power their flashlights. Your task is to design a system that allows them to do this. Before you begin to design your energy system, you will learn about some interesting systems that capture energy from the body's motion.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

Name: _____

Date: _____

Warm-Up



Based on new evidence you gathered from reading the article, do you think a hand-crank flashlight would be a good energy system for the rescue workers? Why or why not? You can review the “Hand-Crank Flashlight” article, if needed.

Active Reading: *Capturing Human Energy*

Part 1: First Read

- Choose one of the articles from the *Capturing Human Energy* article set. Record the title of the article you selected here: _____
- Read and annotate the article, using your Active Reading strategies. You can refer to the Active Reading Guidelines below.

Part 2: Second Read

- Read the same *Capturing Human Energy* article again. Highlight information and add annotations that help answer these questions:
 - How does the system you read about transfer and convert energy to make a generator move?
 - Do you think this system would be a good solution for the rescue team? Why or why not?
- Be prepared to share what you learned with the members of your group.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Discussing Energy Systems

- Group members should take turns to explain the energy system they read about.
 - How does the system transfer and convert energy to make a generator move?
 - Do you think this system would be a good solution for the rescue team? Why or why not?
- As each group member explains an energy system, record brief notes about that energy system in the table below.

Energy system	How does this system make a generator move?	Would the system be a good solution for the rescue team? Why or why not?
Hand-crank flashlight	When a person turns the crank, the generator spins.	No, the rescue workers would need to stop what they are doing to turn the crank.
Energy-capturing backpack		
Energy-capturing bike		
Energy-capturing rocking chair		
Energy-capturing knee brace		

Lesson 3.2: Designing and Explaining Energy Systems

What do *you* think is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions? Today you will work with your group to design an original energy system to accomplish this important job! You will document your energy system and use physical materials to make a model of your design so that the rescue team can understand how it works.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

Digital Tools

- *Harnessing Human Energy* Simulation

Name: _____

Date: _____

Warm-Up

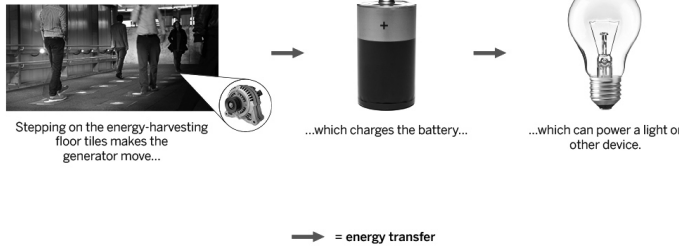


Dear student energy scientists,

I would like you to read about one more system that captures human energy. This might give you more ideas for a system that could work for the rescue team.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

How Energy-Harvesting Floor Tiles Work



Energy-harvesting floor tiles work by compressing a tiny amount when stepped on. A special generator converts this squeezing motion to electrical energy. With each footstep, one tile provides enough energy to power a standard lightbulb for just a fraction of a second.

How could the rescue workers use squeezing or compressing to get energy to their flashlights during rescue missions?

Name: _____

Date: _____

Designing Energy Systems

Remember that the rescue workers need a way to easily get energy to their equipment anytime and anywhere. **What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?**

1. Work with your group to design an original energy system for the rescue team. All group members should participate in designing the system.
2. Share ideas for energy systems. As a group, decide on one energy system to design.
3. Use the Energy System Sketch sheet on the next page to show what your system might look like.
4. Complete the Energy Transfer Diagram sheet on page 54 to show how your energy system captures energy from the body's motion.
5. Use the provided materials to make a model of your energy system. Your system should include
 - a plastic vial or binder clip to represent a generator, and
 - a penny to represent a battery.

Name: _____

Date: _____

Energy System Sketch

In the space below, sketch your energy system. Add labels and captions that help explain how your energy system works. You can use the Word Bank to help you label your sketch. You do not need to use all of the words.

Word Bank

potential energy

transfer

generator

kinetic energy

convert

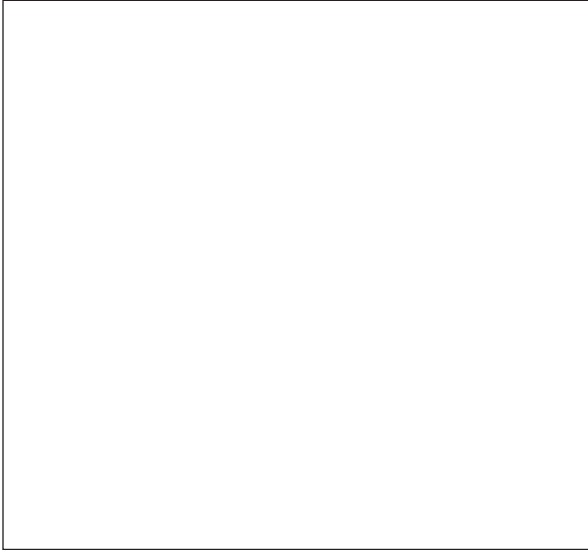
Name: _____

Date: _____

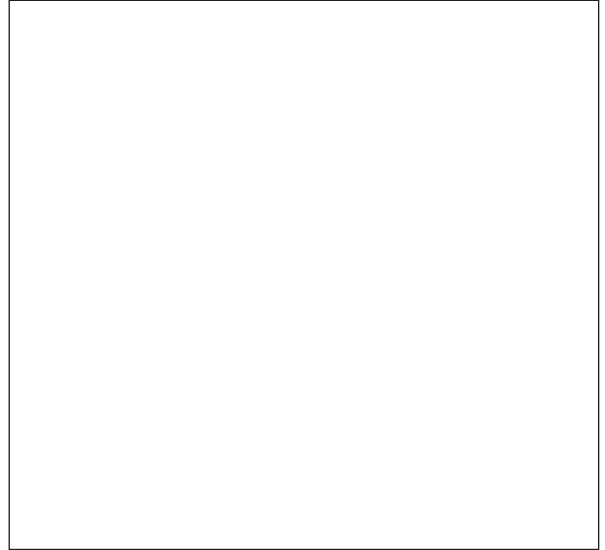
Energy Transfer Diagram

Make an Energy Transfer Diagram, using labels and arrows, to show how your system captured energy from the rescue worker's motion in order to power a flashlight.

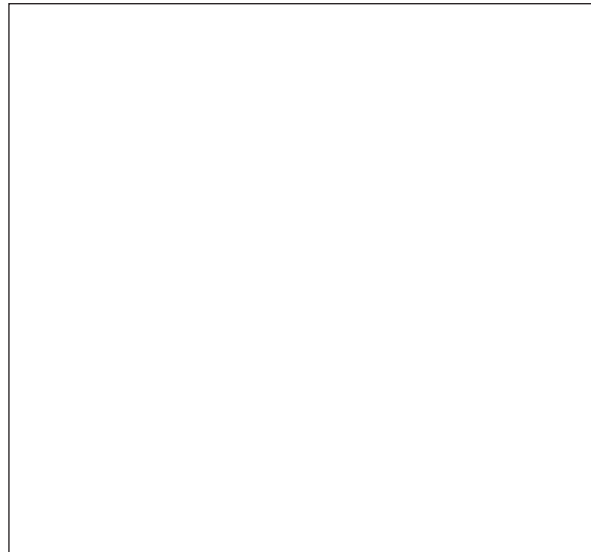
Potential Energy



Kinetic Energy



Light Energy



Homework: Report for the Rescue Team (continued)



Dear student energy scientists,

One of our clients is interested in ways to power lights and other small electronics using energy sources that are available in his environment. This client lives in a sunny, windy, dry environment. I'd like you to use the Simulation to design an energy system for this client and record your ideas below. I look forward to seeing what you come up with!

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

Part 2

1. Launch the Simulation and create an energy system that can meet the needs of the Energy Research Lab client.
2. In the space below, describe the parts of your energy system and explain how energy is transferred and converted in the system to power lights or small electronics.

Lesson 3.3: Evaluating an Energy Solution

The Energy Research Lab was impressed with your energy system designs for the rescue team and would like your help with another client's energy problem. A school principal is interested in saving money on her school's energy costs by capturing energy from students' physical activities while they are at school. She wants to know whether or not the Ed-You-Swivel chair, a new energy-harnessing product, is a good energy solution for her school. In this lesson, you will evaluate evidence about the Ed-You-Swivel to make a recommendation to the principal.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- claim
- energy
- evidence
- kinetic energy
- potential energy
- reasoning
- transfer

Warm-Up

The Energy Research Lab has received a request from a new client. A school principal is interested in saving money on her school's energy costs by capturing energy from students' physical activities while they are at school. She has learned about the Ed-You-Swivel chair, a new energy-harnessing product, and wants to know whether it is a good energy solution for her school.

Read the Ed-You-Swivel brochure below. Use your Active Reading annotation strategies to record questions and connections as you read.

Ed-You-Energy

... helping schools save energy since 2013

About our company: At Ed-You-Energy, we are in the business of helping students generate electricity for their schools! We design state-of-the-art furniture and other equipment for schools like yours.

At first glance, you can see that our products are designed with comfort and quality in mind. What you can't see is that each and every Ed-You-Energy product has a built-in electrical generator! These generators convert energy from students' movements to electrical energy and store it in a battery. Schools can use these batteries to power computers, tablets, lights, and more. Think of how much energy YOUR school could save with Ed-You-Energy products!



About the Ed-You-Swivel: The Ed-You-Swivel chair is designed so that students can turn in any direction during class. Students can talk to their partners or look at a chalkboard behind them without wasting time dragging their desks across the floor. Every time students swivel their seats, their movements turn a generator. The generator converts kinetic energy to potential energy that is stored in a battery.

Name: _____

Date: _____

Evaluating Ed-You-Swivel Evidence

Part 1: Evaluating Evidence Based on Reliability of Source

Follow the steps below to evaluate the Ed-You-Swivel evidence with your partner.

1. **Discuss each piece of evidence with your partner.**

- How reliable is the source of the evidence?
- What makes you think that? You can use the sentence starter below to discuss the evidence.
I think this evidence source is very reliable / reliable / not reliable because . . .

2. **Place each evidence card on the Evidence Gradient based on how reliable you think the evidence source is.** Make sure that each evidence card is positioned above cards with less reliable sources and below cards with more reliable sources.

Part 2: Deciding Which Claim the Evidence Supports

3. Place the two Claim Cards side by side at the top of your desk.
4. Discuss each piece of evidence with your partner and decide which claim it supports. Place the Evidence Card under that claim.
5. When you have finished sorting the evidence, select the claim below you think is best supported. Be ready to explain how the evidence supports this claim.

Claim 1: The Ed-You-Swivel chairs will capture enough energy to power the school's small electronics.

Claim 2: The Ed-You-Swivel chairs will not capture enough energy to power the school's small electronics.

Preparing to Write an Argument

Part 1

The Reasoning Tool will help you organize your evidence so you can write a clear and convincing argument for the principal. Select the evidence you want to include, and write it in the left-hand column of the table on page 61. Then, in the middle column, explain why this evidence matters. In the right-hand column, you can write the claim or you can explain in more detail what aspect of the claim is supported.

Evidence

- **Evidence Card A:** A commercial paid for by Ed-You-Energy says that the Ed-You-Swivel “creates” enough energy to power an entire school.
- **Evidence Card B:** Data from the electric company shows that the school uses about 15 million (15,000,000) joules of energy every hour.
- **Evidence Card C:** A magazine called *Future-Tech Today* published an article about the Ed-You-Swivel. The article said that after a few minutes of use, the product would be able to fully charge one tablet. *Future-Tech Today* also published an article about a car that “makes more energy than it uses.”
- **Evidence Card D:** Engineers at Product Testing Lab, Inc. found that the Ed-You-Swivel harnesses 4,000 joules in one day of typical use. It would take an Ed-You-Swivel 20 days to charge one tablet. Product Testing Lab, Inc. is a company used by many businesses, schools, and government agencies to make choices about what to buy.
- **Evidence Card E:** Your friend said that his dad uses the Ed-You-Swivel at work, and it captures enough energy to charge his cell phone.
- **Evidence Card F:** Someone who knows the owner of a company that sells basketballs that harness human energy says that the Ed-You-Swivel will not capture enough energy to charge a cell phone, even if it is used for an entire day.
- **Evidence Card G:** For hundreds of years, scientists have observed that energy cannot be created. If something has energy, the energy must have been transferred from something else.
- **Evidence Card H:** The Ed-You-Swivel developers state that the product can save schools money.

Name: _____

Date: _____

Preparing to Write an Argument (continued)

Part 2

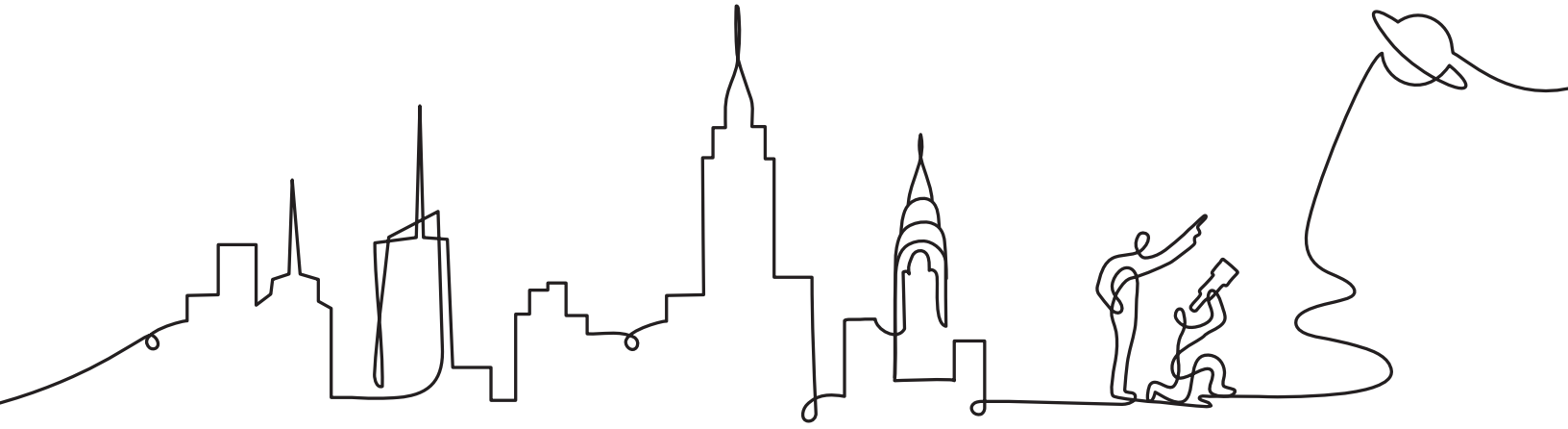
Question: *Can the Ed-You-Swivel chairs capture enough energy to power the school's small electronics?*

Select the claim the evidence supports:

Claim 1: The Ed-You-Swivel chairs will capture enough energy to power the school's small electronics.

Claim 2: The Ed-You-Swivel chairs will not capture enough energy to power the school's small electronics.

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)



New York City Companion Lessons

Name: _____

Date: _____

Investigating Electrical Devices

Part 1: Building Electrical Devices

Use the provided items to make an electrical device where you can turn the light on and off.

Design Diagram

In the space below, draw your energy system, showing the different parts and how they are connected. Add labels and captions that help explain how your energy system works. If you modify your design while building, update your diagram below.

Name: _____

Date: _____

Investigating Electrical Devices (continued)

Reflection Questions

1. How does energy get from the battery to the light?

2. How does your on and off mechanism work? Explain how turning on your device causes energy to get to the light and how turning it off prevents energy from getting to the light.

Name: _____

Date: _____

Investigating Electrical Devices (continued)

Part 2: Designing Solutions for Fixing Broken Electrical Devices

Step 1: Build an electrical device that does not work to light up the lightbulb.

1. How would another group fix the device?

Step 2: Fix another group's broken electrical device.

2. What will you do to fix the broken device? Why will that work to fix the device?

3. Were you able to fix the device?

Name: _____

Date: _____

Investigating Non-Touching Forces

Part 1: Distance and Strength of Magnetic Force

Refer to the investigation plan that you made as a class. Conduct the tests with your partner and record the results below.

Test #	Starting distance between magnets	Distance one magnet moved
1	0 centimeters (touching)	
2	0 centimeters (touching)	
3	0 centimeters (touching)	
4	1 centimeter	
5	1 centimeter	
6	1 centimeter	
7	2 centimeters	
8	2 centimeters	
9	2 centimeters	
10	3 centimeters	
11	3 centimeters	
12	3 centimeters	

What pattern do you think the evidence shows about distance between magnets and strength of magnetic force?

Name: _____

Date: _____

Investigating Non-Touching Forces (continued)

Part 2: Investigating Strength of Forces

1. Which force will you investigate? (check one)

magnetic force

electrostatic force

2. What variable will you investigate?

3. How will you conduct your tests?

4. How will you change that variable between each test?

Name: _____

Date: _____

Investigating Non-Touching Forces (continued)

5. What will you measure and/or observe in order to gather evidence about the strength of the force?

6. What will you keep the same for each test?

7. How many tests will you do?

Name: _____

Date: _____

Investigating Non-Touching Forces (continued)

Part 3: Investigation Results

Record the results of your investigation on this page. Create a data table if it helps to organize your results.

Name: _____

Date: _____

Investigating Non-Touching Forces (continued)

Part 4: Magnetic Device Problem

One team of engineers builds a device that uses repelling magnets to make a cart move. The moving cart has kinetic energy. A second team of engineers tries to build a copy of the device, but the cart does not move as fast. It does not have as much kinetic energy. The second team used the same cart as the first team, but they made their own version of the repelling magnets.

What might the second team have done differently? Describe two magnet variables that might have been changed. For each variable, explain why the change would have caused the cart to move more slowly and to have less kinetic energy.

First possibility:

Second possibility:

Name: _____

Date: _____

Reading About Non-Touching Forces

1. Read and annotate one of the three articles: “Magnetic Force and Rainbow Trout,” “Gravity and Bats,” or “Electrostatic Force and Bees.”
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one that you would like to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- Never
- Almost never
- Sometimes
- Frequently/often
- All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____

Date: _____

Second Read of “Magnetic Force and Rainbow Trout,” “Gravity and Bats,” or “Electrostatic Force and Bees”

Part 1

Reread paragraph 2 of the article you just read. Then describe what you read to each of your group members. As a group, decide which information to highlight. You’re looking for information that helps you understand what the force you read about has in common with the other two non-touching forces that your group members read about. This information will help you answer the questions in Part 2.

What do gravity, electrostatic force, and magnetic force have in common?

Name: _____

Date: _____

Second Read of “Magnetic Force and Rainbow Trout,” “Gravity and Bats,” or “Electrostatic Force and Bees” (continued)

Part 2

1. Think back to the investigations you did in class about non-touching forces. What new information from the article can you use to explain one of the investigations?

2. A space scientist wants to figure out if a magnetic field is present on one of Jupiter’s moons. What could she do to gather evidence about this question?

Harnessing Human Energy Glossary

claim: a proposed answer to a question about the natural world

afirmación: una respuesta propuesta a una pregunta sobre el mundo natural

convert: to change from one type to another

convertir: cambiar de un tipo a otro

electric circuit: a closed path in which an electric current can exist

circuito eléctrico: una trayectoria cerrada en la cual puede existir una corriente eléctrica

electric current: the way that electrical energy is transferred from one place to another (for example, through wires)

corriente eléctrica: la manera en la cual la energía eléctrica es transferida de un lugar a otro (por ejemplo, a través de cables)

electrostatic force: the push or pull between two objects due to their electric charge

fuerza electrostática: el empujón o jalón entre dos objetos debido a su carga eléctrica

energy: the ability to make things move or change

energía: la capacidad de hacer que las cosas se muevan o cambien

evidence: information about the natural world that is used to support or go against (refute) a claim

evidencia: información sobre el mundo natural que se utiliza para respaldar o rechazar (refutar) una afirmación

field: the space around an object in which that object can exert a non-touching force

campo: el espacio que rodea a un objeto, en el cual ese objeto puede ejercer una fuerza sin tocar

force: a push or a pull that can change the motion of an object

fuerza: un empujón o un jalón que puede cambiar el movimiento de un objeto

generator: a machine that can convert kinetic energy into electrical energy

generador: una máquina que puede convertir energía cinética en energía eléctrica

gravity: the force that attracts a body toward the center of Earth, or toward any other physical body having mass

gravedad: la fuerza que atrae a un cuerpo hacia el centro de la Tierra o hacia cualquier otro cuerpo físico que tiene masa

Harnessing Human Energy Glossary (continued)

kinetic energy: the energy that an object has because it is moving

energía cinética: la energía que tiene un objeto porque se está moviendo

magnetic force: the push or pull between two magnets, or the pull of a magnet on some kinds of metal

fuerza magnética: el empujón o jalón entre dos imanes, o el jalón entre un imán y algunos tipos de metal

model: an object, diagram, or computer program that helps us understand something by making it simpler or easier to see

modelo: un objeto, diagrama o programa de computadora que nos ayuda a entender algo haciéndolo más simple o fácil de ver

potential energy: the energy that is stored in an object or system

energía potencial: la energía que está almacenada en un objeto o sistema

reasoning: the process of making clear how your evidence supports your claim

razonamiento: el proceso de aclarar cómo tu evidencia respalda tu afirmación

scientific argument: a claim supported by evidence

argumento científico: una afirmación respaldada por evidencia

system: a set of interacting parts forming a complex whole

sistema: un conjunto de partes que interactúan formando un todo complejo

transfer: to move from one object to another or one place to another

transferir: mover de un objeto a otro o de un lugar a otro

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Harnessing Human Energy

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