AmplifyScience

Magnetic Fields:

Launching a Spacecraft

Investigation Notebook

NYC Edition

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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: _____

Magnetic Fields: Launching a Spacecraft
Unit Overview

The exploration of space is important, exciting, and costly. What if the cost of launching spacecraft into space could be dramatically reduced? Could magnets be the secret to cheaper space travel? In this unit, you'll learn about a model magnetic spacecraft launcher that is being used to develop less expensive ways to explore space. You will investigate how the magnetic spacecraft launcher works and uncover why a recent model launcher test may have gone wrong.

Name: _____ Date: _____

Chapter 1: Modeling Magnetic Force
Chapter Overview

You have been tasked with helping the Universal Space Agency investigate unexpected results from tests of a model magnetic spacecraft launcher. To begin your investigation, you must first learn how a magnetic launcher works by studying systems of magnets. Understanding magnetic force will help you evaluate the surprising results of the test launches.

Name: _____ Date: _____

Lesson 1.2: Introducing the Magnetic Spacecraft

Welcome to your new unit on magnetic fields! You are about to take on the role of student physicists. Today, you will learn about the Universal Space Agency's magnetic spacecraft launcher and start working together to investigate why the agency's new model spacecraft is launching at a much higher speed than they had expected. You will begin by working with magnets and exploring a digital Simulation to figure out how magnets move other objects. The Universal Space Agency is counting on you, so let's get to it!

Unit Question

- Why do magnets move objects in different ways?

Chapter 1 Question

- How can the launcher make the model spacecraft move without touching it?

Vocabulary

- attract
- repel

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

How can a magnet launch something?

In this unit, you will learn about why magnets move objects in different ways, including launching an object into space at different speeds.

Record your initial thinking about the questions below.

How do you think a magnet can cause something to move?

_____

_____

_____

_____

What are the different ways a magnet can move an object?

_____

_____

_____

_____

Name: _____ Date: _____

Introducing the Magnetic Spacecraft

As you watch the video, *Troubleshooting a Magnetic Launcher,* consider the questions below. After watching the video, take a few minutes to discuss the questions with your partner.

- How do you think the launcher can make the spacecraft move without touching it?
- Why do you think the spacecraft's speed was different on the Monday, Tuesday, and Wednesday launches?

Name: _____ Date: _____

Exploring and Simulating Magnets

Investigation Question: *How do magnets move objects?*

1. Observe and gather evidence during each activity to help you answer the Investigation Question.
2. Record your observations below.

Observations from *Exploring Magnets* activity	Observations from *Simulating Magnets* activity

Name: _____ Date: _____

Homework: Rules About Magnets

Decide whether you **agree** or **disagree** with each claim below.

1. Magnets attract some metals. (check one)

   ☐ agree

   ☐ disagree

2. Magnets repel wood. (check one)

   ☐ agree

   ☐ disagree

3. A magnet must be touching an object to repel it. (check one)

   ☐ agree

   ☐ disagree

4. Magnets can move other objects from a distance. (check one)

   ☐ agree

   ☐ disagree

5. Magnets can attract or repel other magnets. (check one)

   ☐ agree

   ☐ disagree

Name: _____ Date: _____

Homework: Reading "Meet a Scientist Who Studied Magnets"

How do scientists know what they know about magnets? To learn more about a scientist who overcame many challenges to make new discoveries about magnets, read and annotate the "Meet a Scientist Who Studied Magnets" article. Then, answer the question below.

What is one interesting thing you learned from this article?

_____

_____

_____

_____

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: _____

Lesson 1.3: Evaluating Magnetic Force Evidence

Good day, student physicists! In this lesson, you will be evaluating evidence another student physicist has collected to decide if you agree with his claim. How can you decide whether or not you can trust his data? What does the data tell you about whether a magnetic force will cause magnets to attract each other, repel each other, or both? How can a visual model help you communicate this information to other people? Let's find out!

Unit Question

- Why do magnets move objects in different ways?

Chapter 1 Question

- How can the launcher make the model spacecraft move without touching it?

Key Concepts

- A magnetic force can attract or repel an object at a distance.

Vocabulary

- attract
- isolate
- magnetic pole
- model
- refute
- repel
- system
- variable

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

Evidence About Magnets

Barry, another student physicist, ran some tests on how magnets affect other magnets. Based on his evidence, Barry has claimed:

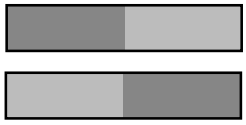
Strong magnets repel and weak magnets attract.

Review Barry's evidence and then answer the questions.

Barry's Evidence

strong magnet 

weak magnet 

	Test 1	**Test 2**
Position of magnets before they were released		
Results when the magnets were released	moved **away** from each other	moved **toward** each other

Do you agree with Barry's claim? (check one)

- ☐ yes
- ☐ no

Do you think his evidence is strong? Why or why not?

_____

_____

_____

_____

Name: _____ Date: _____

Evaluating Evidence

1. Evaluate the evidence on the Evidence Cards that the other student physicists produced to refute Barry's claims.
   - What is different and what is similar about the magnets in the two tests?
   - How many variables were changed for the second test?
2. Based on your evaluation, place the Evidence Cards on the Evidence Gradient. Remember that evidence is stronger when the variable being tested is isolated, which means only one variable is changed at a time.
3. After you evaluate the evidence, complete the poll:

To help show Barry that his claim is inaccurate, select the strongest evidence card to share with him. (check one)

- ☐ Evidence Card A
- ☐ Evidence Card B
- ☐ Evidence Card C
- ☐ Evidence Card D
- ☐ Evidence Card E

Name: _____ Date: _____

Modeling Systems of Magnets

Complete the Modeling Tool activity: Attracting and Repelling Magnets on the next page.

Goal: Create two models. In one model, show two magnets that will **attract.** In the other model, show two magnets that will **repel.** Use the symbols shown in the Key in your models.

Do:

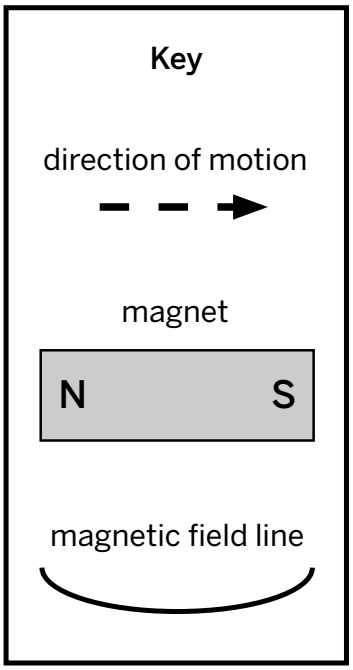
- In the left panel, draw two magnets positioned so that a magnetic force will cause motion.
- In the right panel, show what would happen to the magnets after you let them move freely.

Name: _____ Date: _____

Modeling Systems of Magnets (continued)

Attracting and Repelling Magnets Modeling Tool

	held in place	after release
Attracting magnets		
Repelling magnets		



Name: _____ Date: _____

Homework: Magnetic Launchers and Catchers

How can you build a "magnet catcher" or a "magnet launcher"?

Use the Simulation to complete the tasks below. Draw and label your successful setup for each task.

1. Launch the *Magnetic Fields* Sim. Place a weak magnet horizontally at the bottom of the screen. Set up a locked magnet so it will attract the weak magnet at a distance. If necessary, test and revise your setup until you find a successful solution.

Below, sketch and label the setup for your successful "magnet catcher."

2. Place a weak magnet vertically near the left side of the screen. Set up a locked magnet so it will repel the weak magnet off the right side of the screen. If necessary, test and revise your setup until you find a successful solution.

Below, sketch and label the setup for your successful "magnet launcher."

Name: _____ Date: _____

Lesson 1.4: "Earth's Geomagnetism"

A magnetic force can attract or repel—and may do both things at the same time! When does this happen? Why does this happen? How is this related to the fact that a compass needle will always rotate to point north, no matter where you are on Earth? Today, you will read about the magnetic field that surrounds Earth and learn how scientists visualize the mysterious magnetic force produced by this magnetic field.

Unit Question

- Why do magnets move objects in different ways?

Chapter 1 Question

- How can the launcher make the model spacecraft move without touching it?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.

Vocabulary

- attract
- isolate
- magnetic field
- magnetic field line
- magnetic pole
- model
- repel

Name: _____ Date: _____

Warm-Up

In the center of a compass, there is a small magnet called a needle that points north. When a compass is turned, the needle will rotate until it points north again.

Why do you think a compass needle always points north? (Write your initial ideas. It is okay if you are unsure about them.)

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Reading "Earth's Geomagnetism"

1. Read and annotate the article "Earth's Geomagnetism."
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.

Name: _____ Date: _____

Lesson 1.5: Investigating Magnetic Field Lines

Welcome back, student physicists! The Universal Space Agency needs you to analyze some new data, in the form of diagrams, about the model spacecraft launcher tests. Before you can tackle this assignment, you will need to understand how to use scientific models to predict whether magnets will attract each other, repel each other, or both. In this lesson, you will return to the "Earth's Geomagnetism" article and use the digital Simulation to investigate how scientists model magnetic field lines.

Unit Question

- Why do magnets move objects in different ways?

Chapter 1 Question

- How can the launcher make the model spacecraft move without touching it?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.

Vocabulary

- attract
- magnetic field
- magnetic field line
- magnetic pole
- model
- repel
- system

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

Does a compass always point north? Use the *Magnetic Fields* Simulation to help you determine how a compass needle responds to a magnetic field, and what direction it will point in at different locations around a magnet.

1. In the Sim, place a bar magnet in the center of the screen.
2. Press the Field Lines toggle at the top of the screen to display field lines.
3. Press RUN, then ANALYZE at the top of the screen.
4. Select the COMPASS tool and drag it onto the screen.
5. Move the compass to different locations around the magnet and observe the direction of the compass needle at each location.

What happens to the compass needle as you move the compass around? (check one)

- ☐ The compass needle always points north.
- ☐ The compass needle points in random directions.
- ☐ The compass needle follows the pattern of magnetic field lines.
- ☐ The compass needle's north pole always points to the north pole of the magnet.

Name: _____ Date: _____

Rereading "Earth's Geomagnetism"

Reread the second and third paragraphs in the "Earth's Geomagnetism" article. Then, answer the question.

How are magnetic field line models helpful?

_____

_____

_____

_____

_____

_____

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: _____

Exploring Field Lines

How can you tell whether two magnets will attract each other, repel each other, or do both?

Use the *Magnetic Fields* Simulation to help you answer the questions. Sketch what you see in the Sim to support your answers.

- Turn on Field Lines by pressing the toggle at the top of the screen, then drag two bar magnets onto the screen.
- Try arranging the magnets in several different ways and observe the magnetic field lines as the magnets attract and repel each other.
- Press RUN to observe how the magnets interact.
- Press ANALYZE to review and closely examine field lines.

Part 1: Repelling

What do magnetic field lines look like when two magnets repel? (check one)

- ☐ Most field lines connect a pole of one magnet to a pole of the other magnet.
- ☐ All field lines connect one pole of a magnet to the opposite pole of that same magnet.

Sketch a magnetic field line pattern that represents a repelling force.

Name: _____ Date: _____

Exploring Field Lines (continued)

Part 2: Attracting

What do magnetic field lines look like when two magnets attract? (check one)

- ☐ Most field lines connect one pole of one magnet to the opposite pole of the other magnet.
- ☐ All field lines connect one pole of a magnet to the other pole of that same magnet.

Sketch a magnetic field line pattern that represents an attracting force.

Part 3: Repelling and Attracting

Sketch a magnetic field line pattern that represents both a repelling and an attracting force.

Name: _____ Date: _____

Modeling Magnetic Field Lines

Turn back to your Modeling Tool activity: Attracting and Repelling Magnets on page 15.

Goal: Revise your previous models by adding magnetic field lines to each system of magnets.

Do:

- Make any necessary changes to your previous model to show how your thinking has changed.
- Draw magnetic field lines around the magnets.

Name: _____ Date: _____

Homework: Reading "Painting with Static Electricity"

You have learned a lot about magnetic fields. To learn about a different type of field, read and annotate the "Painting with Static Electricity" article. Then, answer the questions below.

1. What are some ways that electric fields are similar to magnetic fields.

_____

_____

_____

_____

2. What is one way that an electric field is different from a magnetic field?

_____

_____

_____

_____

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: _____

Lesson 1.6: Analyzing Field Line Data

Hello, student physicists! Now you have a better understanding of magnetic force and magnetic field lines, and you're just in time: We have finally received the magnetic field line data Dr. Shapiro promised us from the Universal Space Agency. Does the evidence support or go against the claim that the model spacecraft and launcher magnets were misaligned on Tuesday? Dr. Shapiro is eager to read your analysis, so let's get started!

Unit Question

- Why do magnets move objects in different ways?

Chapter 1 Question

- How can the launcher make the model spacecraft move without touching it?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.
- The pattern of magnetic field lines around attracting magnets is different from the pattern of magnetic field lines around repelling magnets.

Vocabulary

- attract
- magnetic field
- magnetic field line
- magnetic pole
- model
- refute
- repel
- system

Name: _____ Date: _____

Warm-Up

Part 1: Predicting Magnet Motion

Complete the Modeling Tool activity: Predicting Magnet Motion on the next page.

Goal: Use the magnetic field lines to determine the orientation of the magnets in each diagram and to predict how the magnets will move.

Do:

- Label the rest of the poles in each diagram.
- In the "after release" panel, show how the magnets will move when they are released.

Part 2: Discussing Magnetic Field Line Models

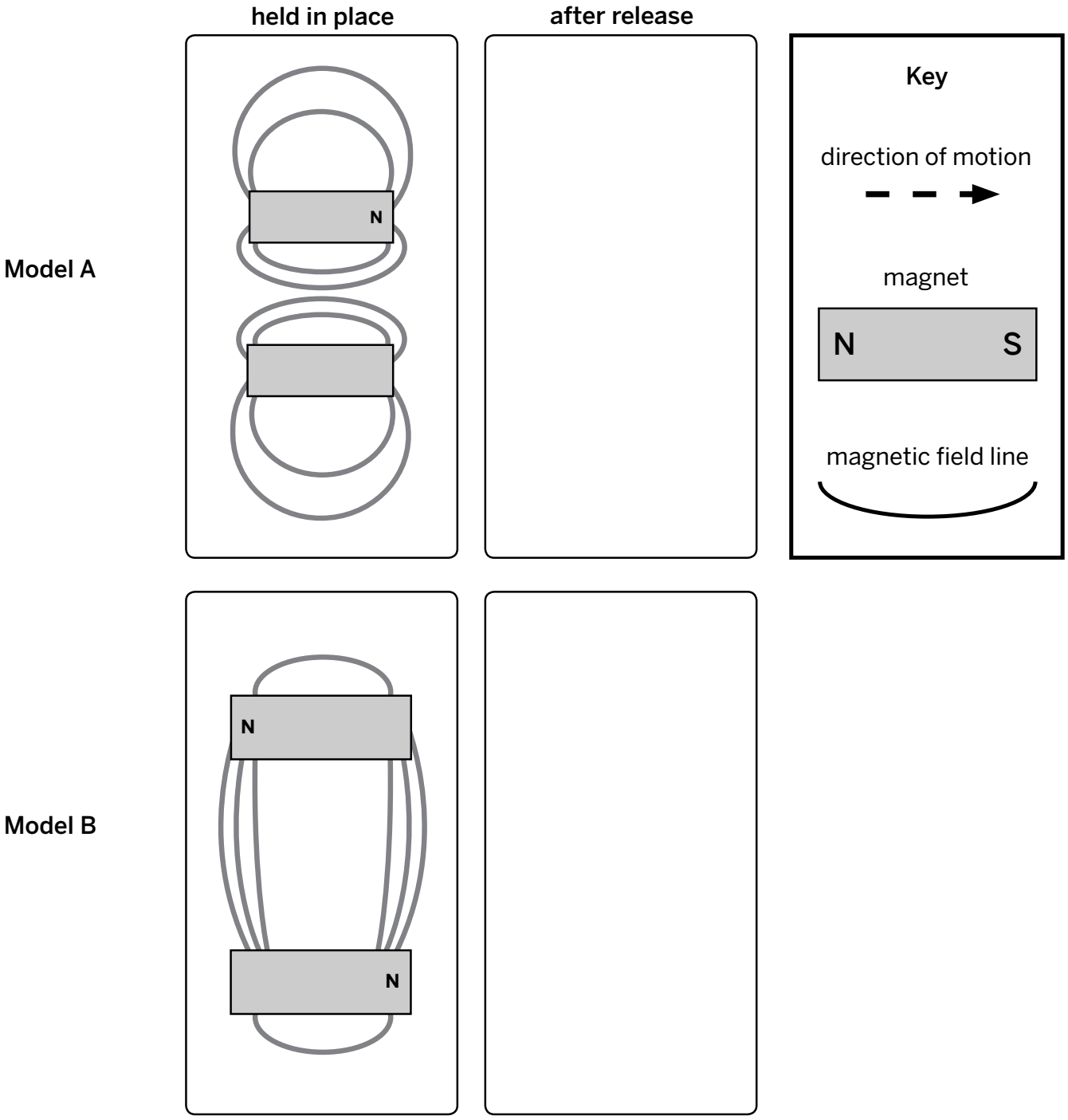
Share the models you just completed with a partner. Discuss the following questions:

- How did you identify where the poles of each magnet should be?
- How did you decide what the position of the magnets would be after they were released?

Name: _____ Date: _____

Modeling Tool: Predicting Magnet Motion

Use the magnetic field lines to determine which way the north and south poles of the magnets are facing in each diagram, then predict how the magnets will move. Use the symbols shown in the Key in your models.

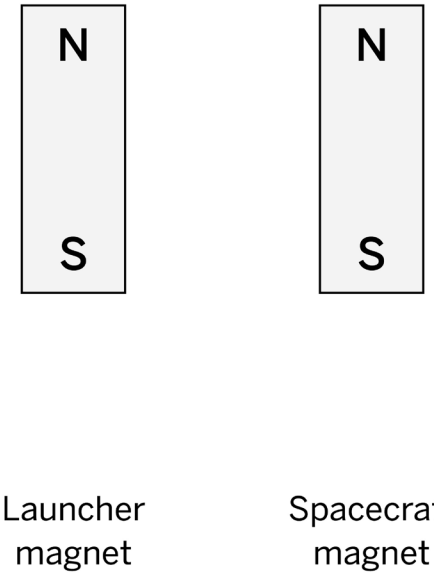


Name: _____ Date: _____

Launcher Alignment

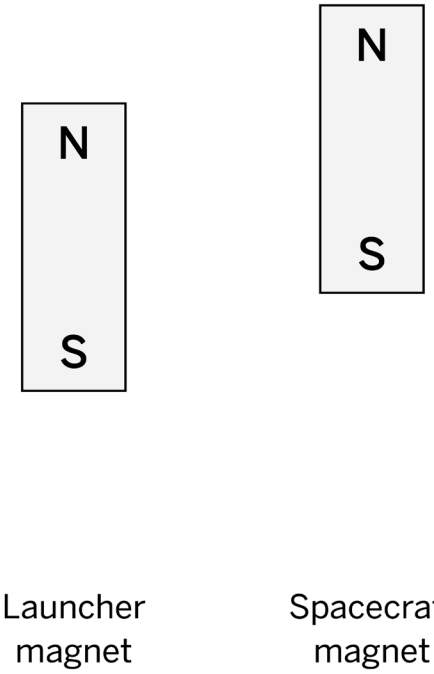
Modeling Magnetic Forces for an Aligned Launcher

Draw the field lines for this aligned magnet system.



Modeling Magnetic Forces for a Misaligned Launcher

Draw the field lines for this misaligned magnet system.



Name: _____ Date: _____

Evaluating a Claim

Dr. Shapiro has asked you to analyze the Magnetic Field Line diagrams and determine whether the data supports the claim that the magnets in the launcher were misaligned during the Tuesday test launch, causing it to be slower than expected.

Explain how the magnetic field line data supports or refutes the claim that the launcher and spacecraft magnets were misaligned in the Tuesday launch. Refer to the words and phrases below to help you write your response.

Word and Phrase Bank

attract	refute	because	therefore
magnetic field lines	repel	if . . ., then . . .	poles
system	system	since	

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the model spacecraft went so much faster than expected on Wednesday?

1. I understand how the launcher can make the model spacecraft move without touching it. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand where the energy to launch the model spacecraft came from. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how force caused different amounts of potential energy to be stored in the launcher system. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how potential and kinetic energy changed during the spacecraft launches. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. What do you still wonder about the magnetic spacecraft launcher?

_____

_____

_____

_____

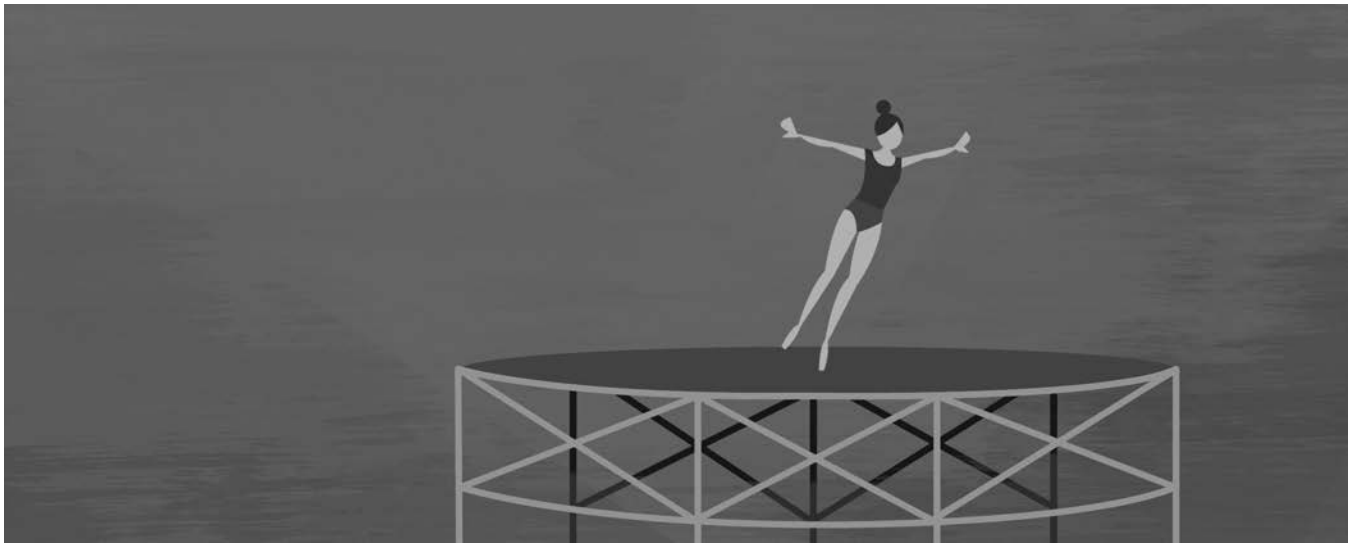
_____

_____

Name: _____ Date: _____

Chapter 2: Investigating Potential Energy
Chapter Overview

Great work on eliminating Claim 1! Now that we know the magnets were not misaligned, we will continue to investigate why the model spacecraft went so much faster than expected in the Wednesday launch. In this chapter, you will investigate the energy in magnetic fields by exploring how magnets get kinetic energy.



Name: _____ Date: _____

Lesson 2.1: The Potential for Speed

Welcome back, student physicists! Great work eliminating the claim that the spacecraft and launcher magnets were misaligned! You will now think about the energy in the system of magnets. In this lesson, you will read an article about an extreme sport to learn how a system can transfer energy to an object (or human) and cause a change in speed. Where is the kinetic energy coming from? How does the kinetic energy get there? What in the world is powerbocking? Let's find out!

Unit Question

- Why do magnets move objects in different ways?

Chapter 2 Question

- Where did the energy to launch the model spacecraft come from?

Vocabulary

- attract
- energy
- kinetic energy
- magnetic field
- potential energy
- repel
- system

Digital Tools

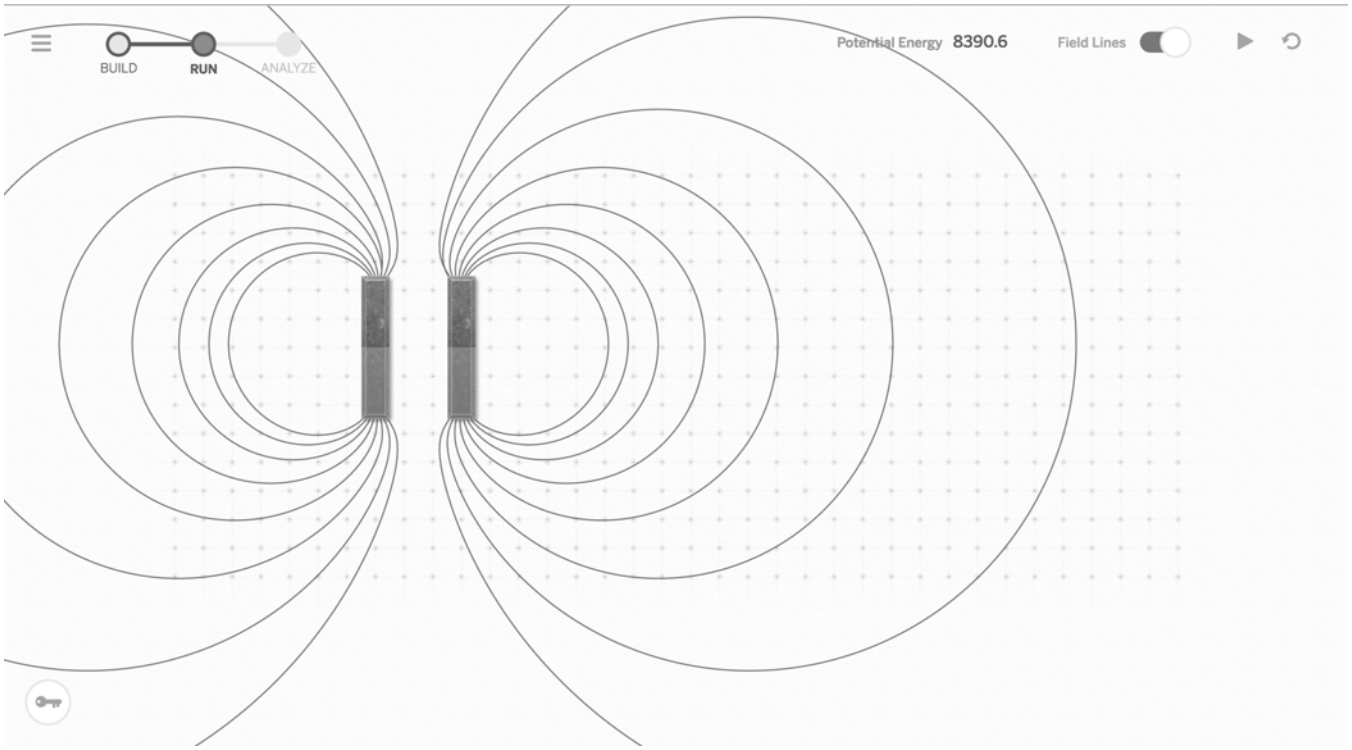
- *Magnetic Fields* Simulation
- *Harnessing Human Energy* Simulation

Name: _____ Date: _____

Warm-Up

How does the energy in a system of magnets change when two magnets repel and move away from each other?

1. In the *Magnetic Fields* Simulation, set up two magnets so that they will move directly away from each other in a straight line.
2. Press RUN to observe the motion of the magnets, then press ANALYZE.
3. Look at the energy graph to see how the amounts of each type of energy in the system change when the magnets move.
4. Circle the bold phrases in the sentence below that reflect your observations.



When the magnets started moving, the amount of (**kinetic energy** / **potential energy** / **thermal energy**) went down and the amount of (**kinetic energy** / **potential energy** / **thermal energy**) went up.

Name: _____ Date: _____

Reading *The Potential for Speed*

1. Read and annotate an article from the article set *The Potential for Speed*
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.

Name: _____ Date: _____

Homework: Simulating Energy Transfers

Use the *Harnessing Human Energy* Simulation to find examples of potential and kinetic energy. Create a system that uses potential and kinetic energy. Name the parts of your system, then answer the questions.

Tips for Using This Simulation

- Press the left and right arrow buttons in the SELECT ENERGY SOURCE box to choose a type of energy.
- Drag devices from the toolbar into the DRAG DEVICES HERE box.
- Press RUN to test your device and observe the types of energy it uses.
- If the blue TRANSFER button appears, press it to see how energy is transferred.
- Press ANALYZE and use the slider to play the test again.

List the items you used in your system, starting with the energy source.

_____

_____

_____

_____

_____

_____

What part (or parts) of your system store potential energy?

_____

What part (or parts) of your system use kinetic energy?

_____

Name: _____ Date: _____

Lesson 2.2: Exploring Potential and Kinetic Energy

Can reading about how a person gets kinetic energy when they participate in an extreme sport help you figure out how a magnet gets kinetic energy when it is moved by another magnet? Where does the kinetic energy come from? Let's find some answers!

Unit Question

- Why do magnets move objects in different ways?

Chapter 2 Question

- Where did the energy to launch the model spacecraft come from?

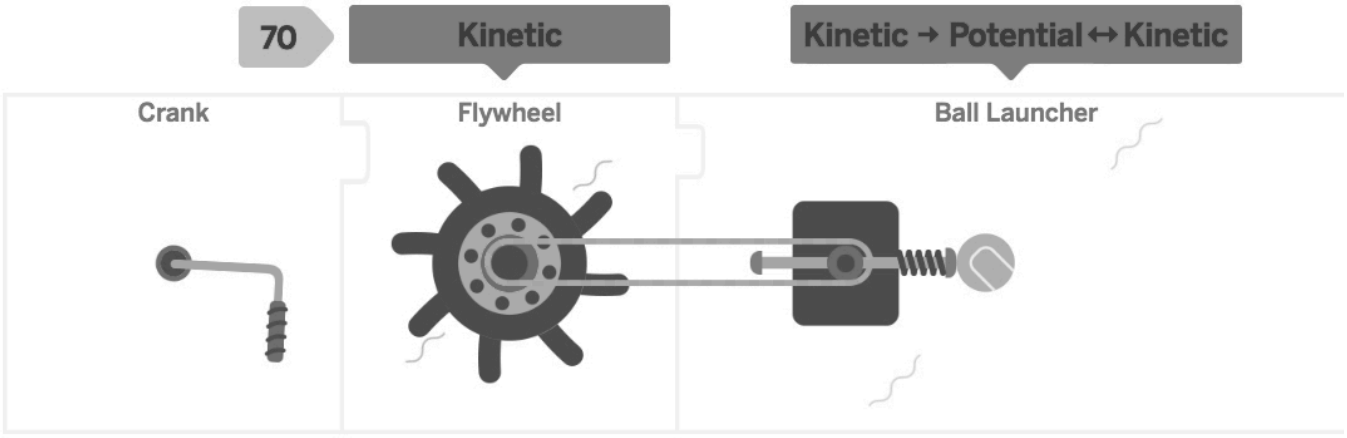
Vocabulary

- attract
- convert
- energy
- kinetic energy
- magnetic field
- potential energy
- repel
- system
- transfer

Name: _____ Date: _____

Warm-Up

This flywheel and ball launcher powered by a hand crank is one possible system that you could have created in your homework assignment.



What part (or parts) of this system store potential energy?

_____

What part (or parts) of this system have kinetic energy?

_____

If an object has kinetic energy, what must it be doing?

_____

_____

Name: _____ Date: _____

Sharing Ideas About Potential Energy

After you reread your article from *The Potential for Speed,* discuss the following prompts with your partner:

- What happens in the sport you read about?
- Where does the kinetic energy people get during that sport come from?

Then, answer the question below.

Moving fast is part of the sport you read about. Where does the kinetic energy people get during the sport come from?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Exploring Energy in Systems

Use the materials on your tray to build three systems, each composed of two parts, that can give an object kinetic energy. For the first system, use any materials. For the next two, use only magnets.

Use the system to gather evidence about the Investigation Question: *How can magnets cause objects to have kinetic energy?*

Define the parts of each system and answer the questions.

System 1

Name two parts of your system. _____ and _____

Describe what happened. When was there more potential energy in the system? When was there more kinetic energy in the system?

_____

_____

_____

_____

System 2 (magnets only)

Name two parts of your system. _____ and _____

Describe what happened. When was there more potential energy in the system? When was there more kinetic energy in the system?

_____

_____

_____

_____

Name: _____ Date: _____

Exploring Energy in Systems (continued)

System 3 (magnets only)

Name two parts of your system. _____ and _____

Describe what happened. When was there more potential energy in the system? When was there more kinetic energy in the system?

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Explanation About Magnets and Kinetic Energy

Explain how the evidence you gathered from reading the article in *The Potential for Speed* and doing the Exploring Energy in Systems activity can help answer the Investigation Question. Try to use all of the words from the Word Bank in your answer.

Word Bank

convert	force	kinetic energy
magnetic field	potential energy	

How can magnets cause objects to have kinetic energy?

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 2.3: Magnetic Force and Potential Energy

All right, student physicists, we still need to figure out where the magnetic launcher system's energy came from and how it got into the system in the first place. In this lesson, you will work in pairs and use the digital Simulation to gather evidence about the relationship between force and energy. You will then work in groups to figure out how energy is transferred into a system.

Unit Question

- Why do magnets move objects in different ways?

Chapter 2 Question

- Where did the energy to launch the model spacecraft come from?

Key Concepts

- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.

Vocabulary

- attract
- convert
- energy
- kinetic energy
- magnetic field
- model
- potential energy
- repel
- system
- transfer

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

Complete the Modeling Tool activity: Potential and Kinetic Energy on the next page.

Goal: Create a model to predict how potential energy (PE) and kinetic energy (KE) change when two magnets repel.

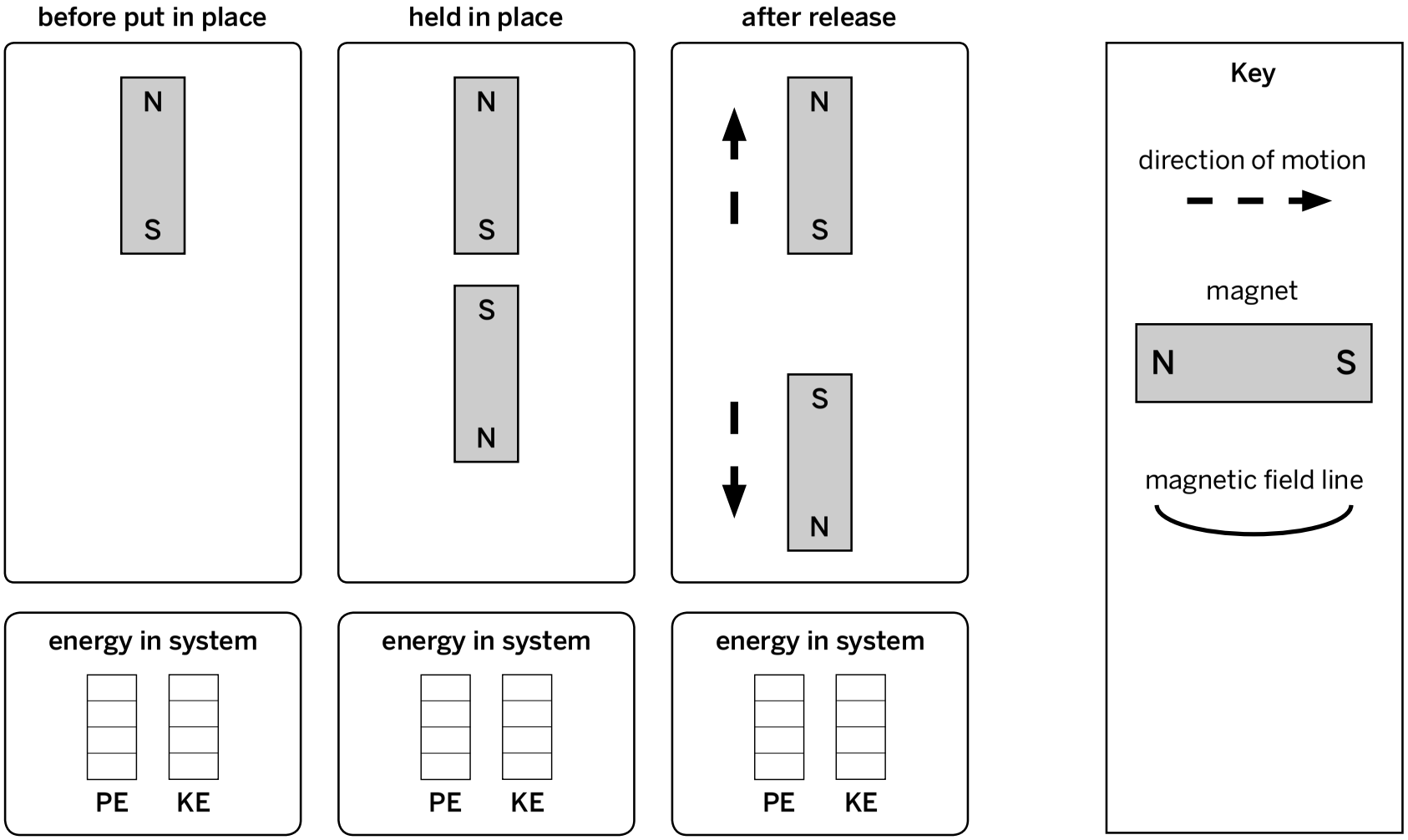
Do:

- Shade in the bar graphs under each panel to show how much potential energy and kinetic energy you think the system has at each time.
- Annotate your model to explain the values of potential energy and kinetic energy for each panel.

Name: _____ Date: _____

Modeling Tool: Potential and Kinetic Energy

Shade in the bar graphs under each panel to show your prediction about how much potential energy (PE) and kinetic energy (KE) the system has at each time. Annotate your model to explain the amounts of energy you have chosen for each panel.



Name: _____ Date: _____

Simulating Energy Changes

Part 1: Investigating Changes in Energy

Use the *Magnetic Fields* Simulation to look for evidence and to evaluate the following set of claims about force and potential energy:

> **Claim A:** Potential energy increases when a magnet is moved *with* (in the same direction as) the magnetic force.
>
> **Claim B:** Potential energy increases when a magnet is moved *against* (in the opposite direction from) the magnetic force.

One pair of students will test the claims for attracting magnets, and the other pair will test the claims for repelling magnets. You will share your results.

Follow these steps to test each claim. Observe the potential energy in the system after each step. Record your observations in the data tables on the next page.

1. Decide which pair will test the claims for attracting magnets and which pair will test the claims for repelling magnets. Find the appropriate table for the claim you and your partner are testing.
2. Create a system of magnets that are a medium distance apart. Record the initial potential energy in the first column of your table.
3. Move the second magnet with (in the same direction as) the magnetic force. Record the potential energy in the second column of your table.
4. Now move the second magnet against (in the opposite direction from) the magnetic force. Record the potential energy in the third column of your data table.
5. Share your results with the other members of your group and record the other pair's results in the other data table.

Name: _____ Date: _____

Simulating Energy Changes (continued)

System of Attracting Magnets

Initial potential energy	Potential energy when moved *with* magnetic force (toward)	Potential energy when moved *against* magnetic force (away)

System of Repelling Magnets

Initial potential energy	Potential energy when moved *with* magnetic force (away)	Potential energy when moved *against* magnetic force (toward)

Part 2: Potential Energy in Magnet Systems

Complete the poll below. It is okay if you are unsure about your answer.

My evidence supports the claim (or claims) that: (choose all that apply)

- ☐ **Claim A:** Potential energy increases when a magnet is moved *with* (in the same direction as) the magnetic force.
- ☐ **Claim B:** Potential energy increases when a magnet is moved *against* (in the opposite direction from) the magnetic force.

Explain how your evidence supports the claim (or claims).

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share 1: Spring and Pom Pom

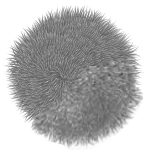
- Carefully read your evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

force	potential energy	store	system	transfer

Evidence Card A: Spring and Pom Pom

I tried launching a pom pom with a spring a few times. The pom pom didn't launch until after I pushed down on the spring, placed the pom pom on it, and then let go.



The kinetic energy of the pom pom came from potential energy in the system.

How did potential energy get stored in the spring/pom pom system?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share 2: Magnet and Iron Rod

- Carefully read your evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

potential energy	system	transfer	store

Evidence Card B: Magnet and Iron Rod

In the Sim, I observed that the amount of potential energy changed as I moved an iron rod away from a magnet. When the rod and magnet were released, they moved toward each other.

My steps	Potential energy	Arrangement of objects
I placed a magnet and an iron rod in the Sim	948 J	
I moved the iron rod away from the magnet	1003 J	

The kinetic energy of the attracted magnet and iron rod came from potential energy in the system.

How did potential energy get stored in the magnet/iron rod system?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share 3: Rubber Band and Pom Pom

- Carefully read your evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

potential energy	system	transfer	store

Evidence Card C: Rubber Band and Pom Pom

I tried launching a pom pom with a rubber band a few times. The pom pom didn't launch from the rubber band until after I stretched the rubber band and then let go.

The kinetic energy of the launched pom pom came from potential energy in the system.

How did potential energy get stored in the rubber band/pom pom system?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 2.4: Simulating Spacecraft Energy

Hello, student physicists! It's time to wrap up this chapter and take a closer look at Claim 2. You'll use your new knowledge about force and energy to figure things out, so we'll begin by reviewing what you've learned. Then you will simulate the spacecraft launches to see if it's possible that the spacecraft traveled so much faster on Wednesday because the launcher system had much more energy. Let's find an answer for the USA today!

Unit Question

- Why do magnets move objects in different ways?

Chapter 2 Question

- Where did the energy to launch the model spacecraft come from?

Key Concepts

- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.
- The energy used to move a magnet against a magnetic force is stored as potential energy in the magnetic field.

Vocabulary

- attract
- convert
- energy
- kinetic energy
- magnetic field
- model
- potential energy
- repel
- system
- transfer

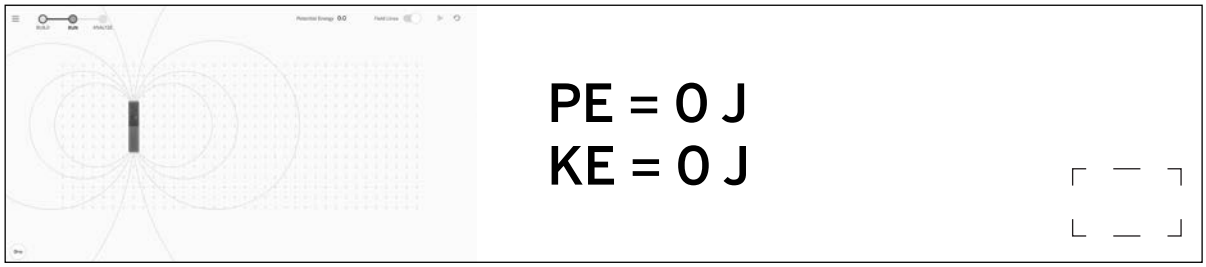
Digital Tools

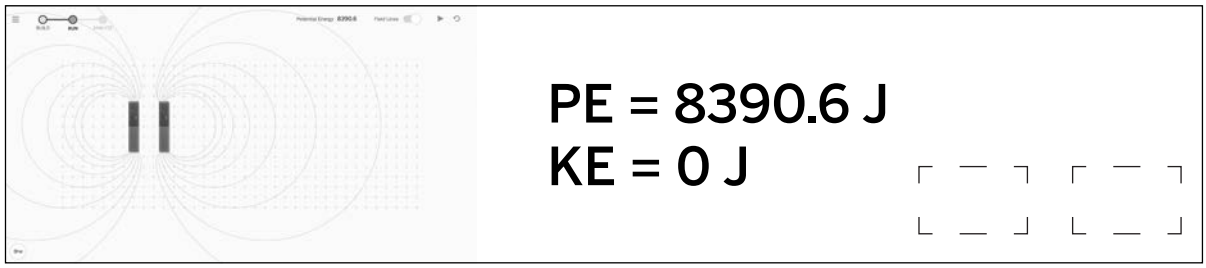
- *Magnetic Fields* Simulation

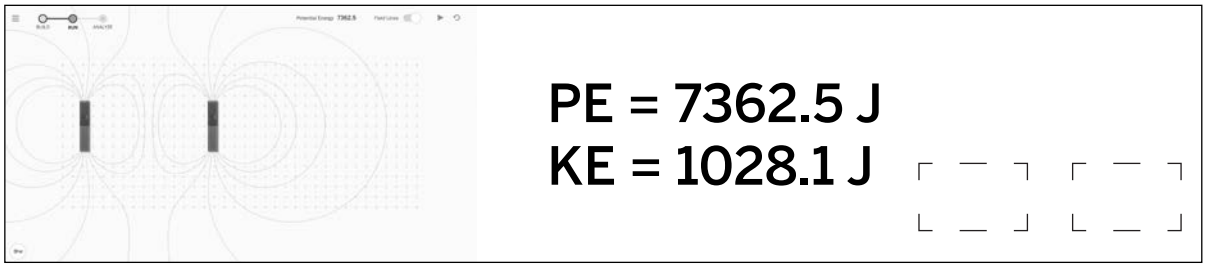
Name: _____ Date: _____

Warm-Up

Examine the series of images from the Sim that show potential energy levels (PE) and kinetic energy levels (KE) in only one magnet, as a second magnet is placed, and when both magnets are released. Label each box with letters from the statements below that are true for the image shown in the box. You do not need to use all the letters.







A. Potential energy was stored in the magnet.

B. A force converted potential energy to kinetic energy.

C. The magnets were released.

D. A magnet was moved against a force.

E. Potential energy was transferred into the system.

F. This is not a system.

Name: _____ Date: _____

Simulating Spacecraft Launch Energy

Why did the model spacecraft go so much faster than expected on Wednesday?

Use the *Magnetic Fields* Simulation to gather evidence for or against the claim that much more energy was in the launcher system on Wednesday than on Tuesday.

1. Place one weak magnet toward the left of the screen, with its north pole facing up. Lock this "launcher" magnet in place.
2. Place the second weak magnet, the "spacecraft" magnet, to the right of the launcher magnet with its north pole facing up. Position the spacecraft magnet the indicated number of grid points away from the launcher magnet.
3. Record the initial potential energy.
4. Press RUN to observe the movement of the spacecraft magnet.
5. Press ANALYZE to review the changes in potential energy and kinetic energy during the launch.
6. Record the amounts of potential energy and kinetic energy after the launch in the table below.
7. Return to BUILD and repeat steps 2–6 to simulate the remaining launches.
8. Respond to the questions on the next page.

Modeled test launch	**Potential energy in the system *before* launch**	**Potential energy in the system *after* launch**	**Kinetic energy in the system after launch**
Monday (4 grid points between magnets)			
Tuesday (3 grid points between magnets)			
Wednesday (2 grid points between magnets)			

Name: _____ Date: _____

Simulating Spacecraft Launch Energy (continued)

Does this evidence support or refute the claim that there was much more energy in the launcher system on Wednesday than on Tuesday? Explain.

_____

_____

_____

_____

Describe the changes in energy for the tests.

What energy conversion(s) did you see?

_____

_____

Which test resulted in the greatest amount of kinetic energy?

_____

Name: _____ Date: _____

Modeling Spacecraft Launch Energy

Complete the Modeling Tool activity: Spacecraft Launch Energy on the next page.

Goal: Create two models to compare the amounts of energy involved in the Tuesday and Wednesday spacecraft launches.

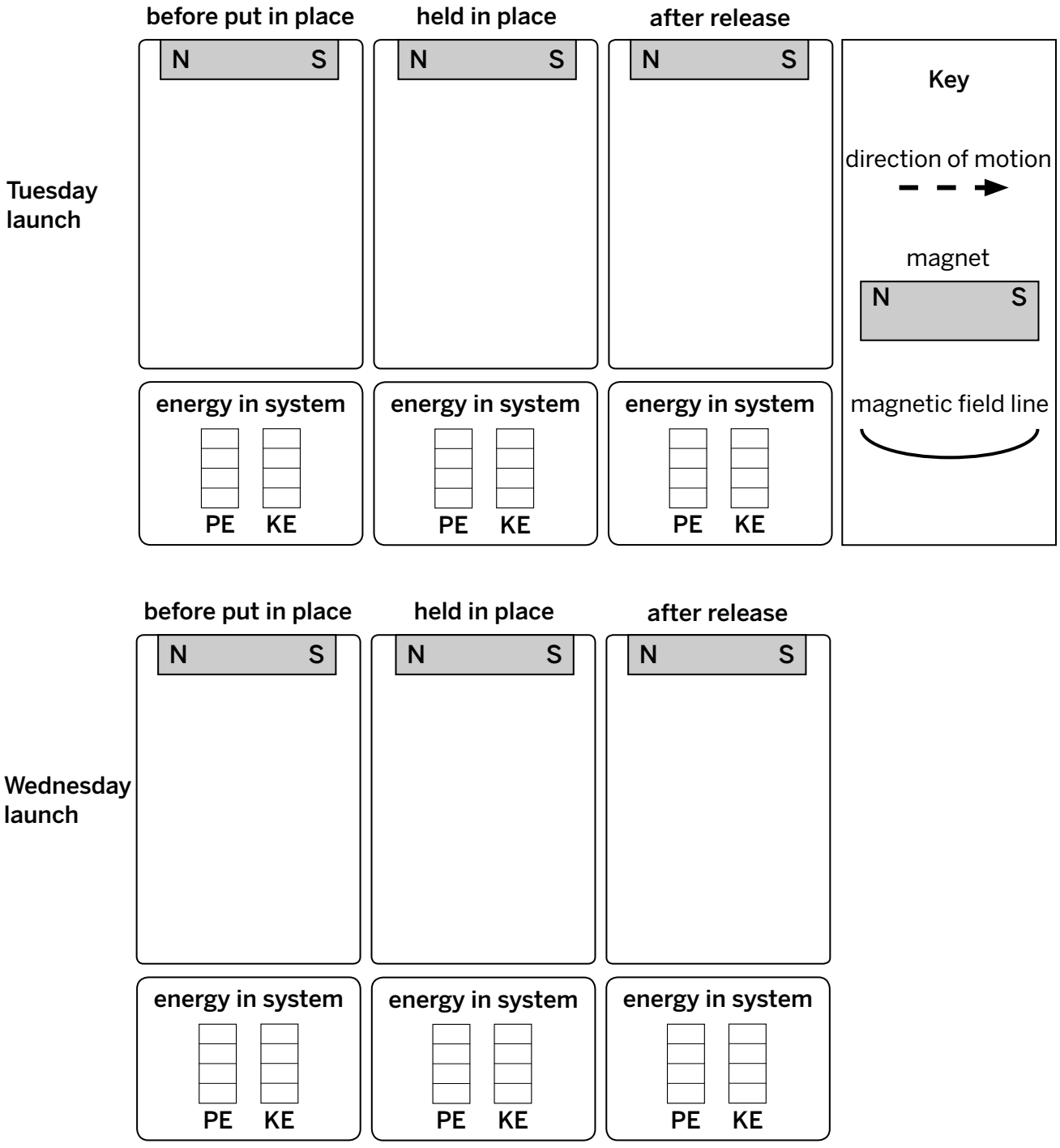
Do:

- In the "held in place" panel, show the starting location of the spacecraft by drawing a magnet to represent it.
- In the "after release" panel, show how the spacecraft magnet moved.
- Shade in the amounts of energy in the system for each panel.
- Add magnetic field lines to each panel.
- Annotate your models to indicate parts of the system and show how force is related to potential and kinetic energy.

Name: _____ Date: _____

Modeling Tool: Spacecraft Launch Energy

Create two models to compare the amounts of potential and kinetic energy in the Tuesday and Wednesday spacecraft launches. Use a magnet to represent the spacecraft in each launch. Use the symbols shown in the Key in your models.



Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below and on the next page.

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the model spacecraft went so much faster than expected on Wednesday?

1. I understand how the launcher can make the model spacecraft move without touching it. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand where the energy to launch the model spacecraft came from. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how force caused different amounts of potential energy to be stored in the launcher system. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how potential and kinetic energy changed during the spacecraft launches. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. What do you still wonder about the magnetic spacecraft launcher?

_____

_____

_____

_____

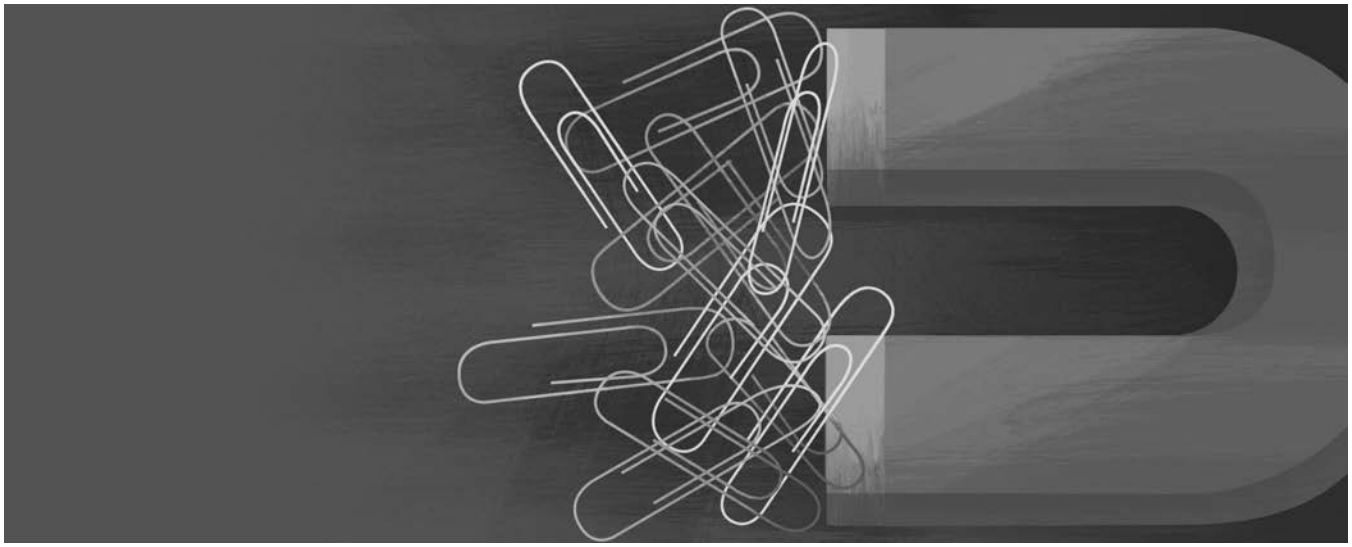
_____

_____

Name: _____ Date: _____

Chapter 3: Exploring the Strength of Magnetic Force
Chapter Overview

Now that you know there was more energy in the launcher system on Wednesday, you will evaluate whether the magnetic force was stronger on Wednesday. To do this, you will investigate how moving against a force can store more energy. This will give you the information you need to solve the spacecraft problem. Dr. Shapiro is eager to receive your results!



Name: _____ Date: _____

Lesson 3.1: Exploring Energy and Force Strength

Welcome back, student physicists! You've done some excellent work gathering evidence about the claims in this unit. We know that the magnets were not misaligned on Tuesday, and we have some evidence to suggest that there may have been more energy in the system on Wednesday, but we still don't know why. Was the magnetic force different on Wednesday? How can a magnetic force cause different amounts of energy to be stored in a system?

Unit Question

- Why do magnets move objects in different ways?

Chapter 3 Question

- Why was there so much more potential energy stored in the launcher system on Wednesday than on Tuesday?

Vocabulary

- attract
- convert
- energy
- isolate
- kinetic energy
- magnetic field
- magnetic pole
- potential energy
- repel
- system
- transfer
- variable

Name: _____ Date: _____

Warm-Up

Safety Note: Strong Magnets
The strong magnets can shatter if dropped on a hard surface and can also pinch skin. Use safety goggles if directed by your teacher, and take care not to throw or drop the magnets.

What is the effect of moving a magnet against a stronger force?

- Arrange two magnets so they are repelling, and push them together.
- One magnet is your "launcher" magnet and the other is your "spacecraft" magnet.
- Release the "spacecraft" magnet.
- Respond to the questions below with your initial ideas.
- Don't worry if you are uncertain. You will have the opportunity to investigate force and energy in this lesson.

1. What happened when you pushed the magnets together? What happened when you let go?

   When I pushed the magnets together, I felt _____.

   When I let go, the spacecraft magnet _____.

2. If you moved the spacecraft magnet against a stronger force, what would happen? (check one)

   ☐ More potential energy would be stored in the magnetic field, and the spacecraft magnet would travel farther/faster.

   ☐ Less potential energy would be stored in the magnetic field, and the spacecraft magnet would not travel as far or as fast.

   ☐ The same amount of potential energy would be stored in the magnetic field, and the spacecraft magnet would travel the same distance at the same speed.

   ☐ More potential energy would be stored in the magnetic field, but the launcher magnet would travel the same distance at the same speed.

Name: _____ Date: _____

Exploring Force and Potential Energy

Safety Note: Strong Magnets
The strong magnets can shatter if dropped on a hard surface and can also pinch skin. Use safety goggles if directed by your teacher, and take care not to throw or drop the magnets.

Part 1: Planning Your Investigation

Discuss with your partner how you will test each claim and answer the questions below.

Claim A: More potential energy can be stored by moving against the magnetic force of a **stronger magnet.**

Which variable will you test and which variable(s) will you keep the same?

_____

_____

_____

Claim B: More potential energy can be stored by moving against the magnetic force **closer to a magnet.**

Which variable will you test and which variable(s) will you keep the same?

_____

_____

_____

How will you measure the effect of each variable?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Exploring Force and Potential Energy (continued)

Part 2: Gathering Evidence About Claims

What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

Instructions for Each Claim

1. Using your plan, conduct an experiment to gather evidence about the claim. Revise your plan, if needed.
2. Before you begin, decide how you will set up your data table so there is a place to record each variable and the test results.
3. Conduct each test and record your data.

Evidence About Claim A:

(More potential energy can be stored by moving against the magnetic force of a stronger magnet.)

Complete this sentence:

More potential energy is stored in a system when _____

_____ and my

evidence is_____.

Name: _____ Date: _____

Exploring Force and Potential Energy (continued)

Evidence About Claim B:
(More potential energy can be stored by moving against the magnetic force closer to a magnet.)

Complete this sentence:

More potential energy is stored in a system when _____

_____ and my

evidence is _____.

Name: _____ Date: _____

Homework

Why was the magnetic force stronger in the Wednesday launch?

Today, you experienced how a magnet can have a stronger magnetic force and how moving against this force transfers more potential energy to the magnetic field. If the magnetic force was stronger in the Wednesday launch, it would have caused more energy to be transferred into the launcher system which would give the spacecraft much more kinetic energy.

Record any ideas or questions you have about the question below. It is okay if you are not sure. You will investigate this question further in the next lesson.

Why was the magnetic force produced by the launcher system so much stronger in the Wednesday launch than in the Tuesday launch, even though the spacecraft was moved the same distance closer?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 3.2: Investigating Magnetic Force Strength

Today, you'll gather and discuss your last pieces of evidence about the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force. You'll run tests in the Sim and examine diagrams. Soon you'll be ready to explain why moving the launcher and spacecraft the same distance closer for the Wednesday launch had so much more of an effect on the spacecraft's speed than the move that was made for the Tuesday launch.

Unit Question

- Why do magnets move objects in different ways?

Chapter 3 Question

- Why was there so much more potential energy stored in the launcher system on Wednesday than on Tuesday?

Vocabulary

- attract
- convert
- energy
- kinetic energy
- magnetic field
- magnetic pole
- model
- potential energy
- repel
- system
- transfer

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

Today, you will continue to investigate claims about the Investigation Question: *What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?*

Claim A: More potential energy can be stored by moving against the magnetic force of **a stronger magnet.**

Claim B: More potential energy can be stored by moving against the magnetic force **closer to a magnet.**

Answer the questions about Claim A below and Claim B on the next page. It is okay if you are unsure about one or both of the claims. You will gather more evidence about these claims in this lesson.

Do you agree with **Claim A,** More potential energy can be stored by moving against the magnetic force of **a stronger magnet?** (check one)

- ☐ Definitely.
- ☐ I think so.
- ☐ I don't know.
- ☐ I don't think so.
- ☐ Definitely not.

Explain why, using evidence from the activities you have done.

_____

_____

_____

_____

_____

Name: _____ Date: _____

Warm-Up (continued)

Do you agree with **Claim B,** More potential energy can be stored by moving against the magnetic force **closer to a magnet?** (check one)

- ☐ Definitely.
- ☐ I think so.
- ☐ I don't know.
- ☐ I don't think so.
- ☐ Definitely not.

Explain why, using evidence from the activities you have done.

_____

_____

_____

_____

_____

Name: _____ Date: _____

Simulating Magnetic Force

What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

Claim A: More potential energy can be stored by moving against the magnetic force of **a stronger magnet.**

Claim B: More potential energy can be stored by moving against the magnetic force **closer to a magnet.**

Turn on Field Lines and use the SENSOR tool in the *Magnetic Fields* Simulation to find evidence about each claim. Describe your evidence below.

If you have time after you finish finding your evidence, turn to the next page and complete the "Build the Best Launcher" mission.

Describe the tests you conducted and the evidence you found to support or refute **Claim A.**

_____

_____

_____

_____

_____

Describe the tests you conducted and the evidence you found to support or refute **Claim B.**

_____

_____

_____

_____

_____

Name: _____ Date: _____

Simulating Magnetic Force (continued)

Optional Mission: Build the Best Launcher

Use what you have learned to build the best magnetic launcher system possible in the *Magnetic Fields* Simulation.

Sketch your launcher system. Label the type(s) of magnets you used.

How much potential energy can your launcher system store? _____

Name: _____ Date: _____

Write and Share 1: Simulation

- Review the evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

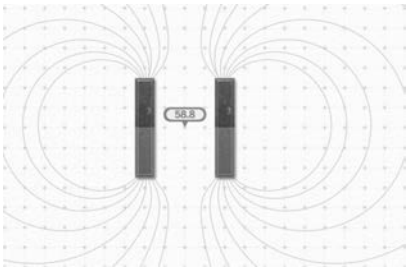
magnetic field	force	potential energy

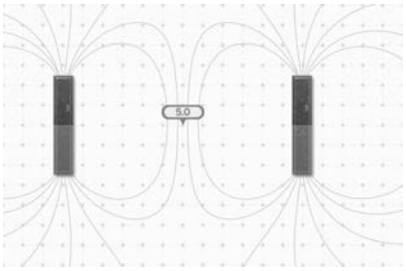
Other helpful words

closer	farther	stronger	weaker

Evidence Card 1: Simulation

The sensor reading showed that the force was stronger when the magnets were closer together.





What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share 2: Repelling Magnets

- Review the evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

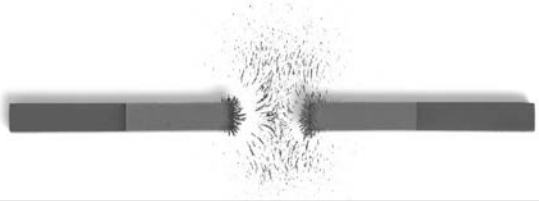
magnetic field	force	potential energy

Other helpful words

closer	farther	stronger	weaker

Evidence Card 2: Repelling Magnets

It was harder to push the magnets together as they got closer together.



What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share 3: Attracting Magnets

- Review the evidence card and write an answer to your specific prompt below.
- Answer your prompt, using the vocabulary words listed in the Word Bank below.
- After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
- While one student is presenting, the other two listen carefully.
- After each student presents, the other students in the group can ask questions or make comments.

Word Bank

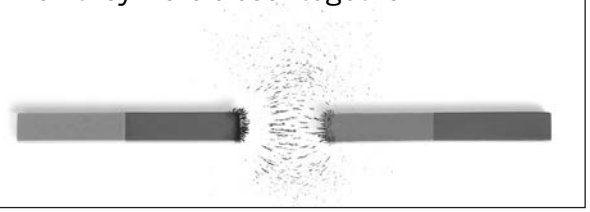
magnetic field	force	potential energy

Other helpful words

closer	farther	stronger	weaker

Evidence Card 3: Attracting Magnets

It was harder to pull the magnets apart when they were closer together.



What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share: Revisiting the Claims

After all your group members have shared their sentences, record your current thoughts about the claims, below and on the next page.

What affects the amount of potential energy stored in the magnetic field when a magnet is moved against a magnetic force?

Claim A: More potential energy can be stored by moving against the magnetic force of **a stronger magnet.**

Claim B: More potential energy can be stored by moving against the magnetic force **closer to a magnet.**

Do you agree with **Claim A,** More potential energy can be stored by moving against the magnetic force of **a stronger magnet?** (check one)

- ☐ Definitely.
- ☐ I think so.
- ☐ I don't know.
- ☐ I don't think so.
- ☐ Definitely not.

Explain why, using evidence from the Simulation and hands-on activities.

_____

_____

_____

_____

_____

Name: _____ Date: _____

Write and Share: Revisiting the Claims (continued)

Do you agree with **Claim B,** More potential energy can be stored by moving against the magnetic force **closer to a magnet?** (check one)

- ☐ Definitely.
- ☐ I think so.
- ☐ I don't know.
- ☐ I don't think so.
- ☐ Definitely not.

Explain why, using evidence from the Simulation and hands-on activities.

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Modeling Force and Energy

Complete the Modeling Tool activity: Force and Energy on the next page.

Goal: Model the system of strong magnets and the system of weak magnets, then compare the energy in each system.

Do:

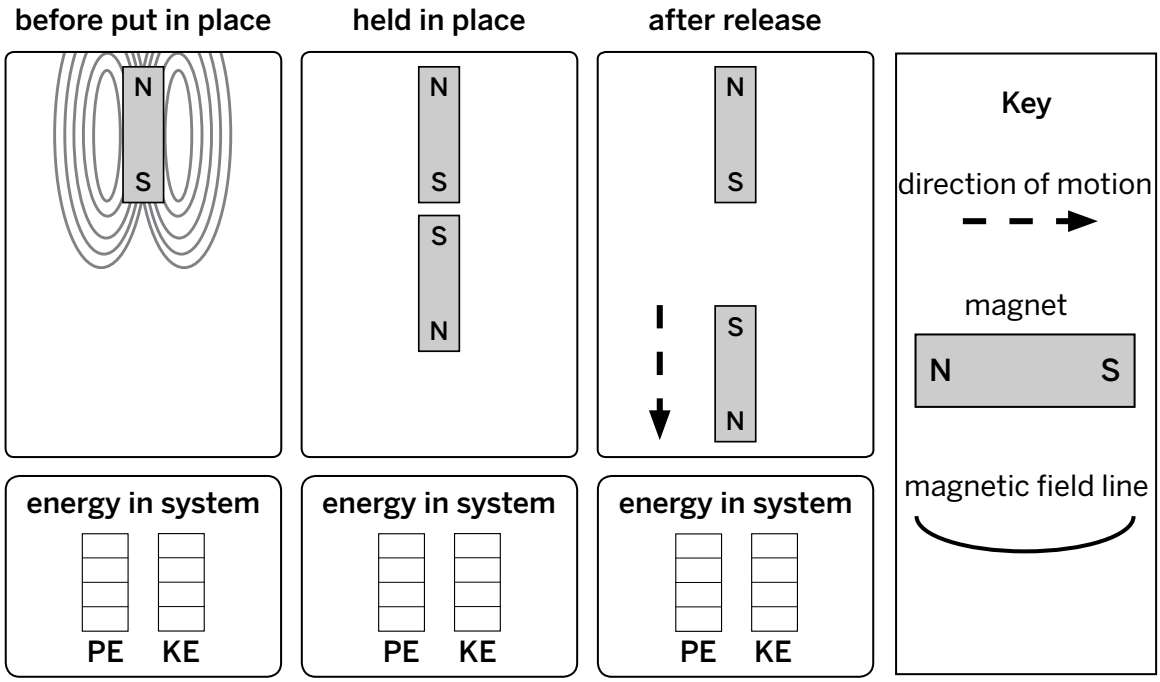
- Decide which model will show a system of strong magnets and label it "Strong." Label the other model "Weak."
- Draw magnetic field lines for each model.
- Shade in the bar graphs for each panel to show the amounts of potential energy and kinetic energy in the system.
- Annotate your models to show where the magnetic force is strongest.

Name: _____ Date: _____

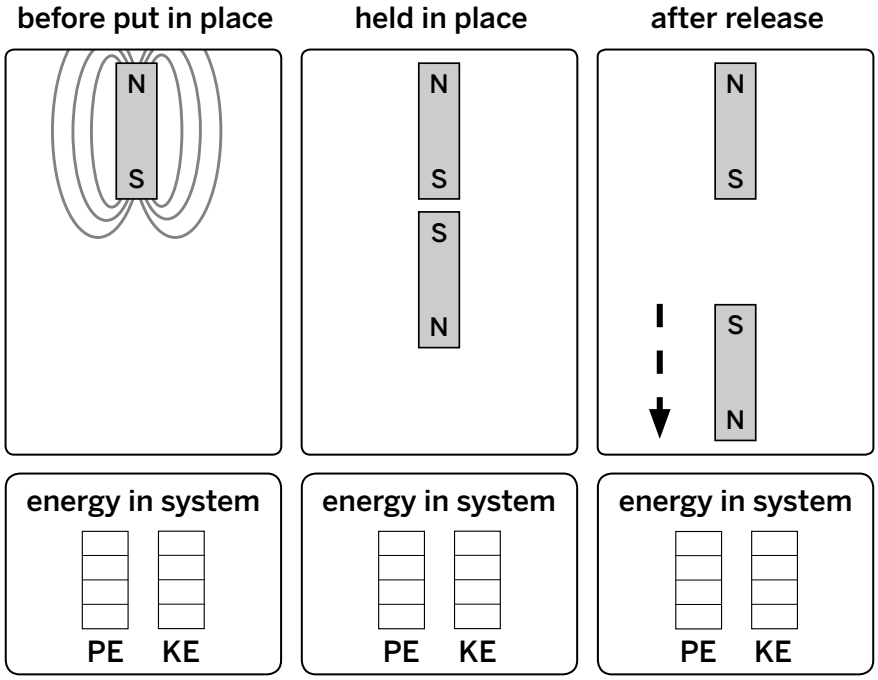
Modeling Tool: Force and Energy

Model the system of strong magnets and the system of weak magnets, then compare the energy in each system. Use the symbols shown in the Key in your models.

Model 1



Model 2



Name: _____ Date: _____

Homework: Reading "Escaping a Black Hole"

Black holes are called black holes because nothing can escape them—not even light! What is it about black holes that allows them to pull other objects toward them with such strong force? Read and annotate the "Escaping a Black Hole" article. Then, answer the questions below.

Why do astronauts on the Moon seem like they're "walking on springs," while on Earth, we are firmly attached to the ground?

_____

_____

_____

_____

Why are black holes black?

_____

_____

_____

_____

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: _____

Lesson 3.3: Modeling the Spacecraft Launches

It is time, student physicists, to analyze the last pieces of data and write a final explanation for the Universal Space Agency. You'll need to use all of your knowledge of potential and kinetic energy, magnetic force, and magnetic fields to get to the bottom of this problem. Why did the spacecraft go so much faster than expected on Wednesday? Let's solve this once and for all!

Unit Question

- Why do magnets move objects in different ways?

Chapter 3 Question

- Why was there so much more potential energy stored in the launcher system on Wednesday than on Tuesday?

Key Concepts

- Moving a magnet against a stronger magnetic force transfers more energy to the magnetic field.
- A magnetic force is stronger closer to a magnet.

Vocabulary

- attract
- convert
- energy
- kinetic energy
- magnetic field
- magnetic field lines
- magnetic pole
- model
- potential energy
- refute
- repel
- system
- transfer

Name: _____ Date: _____

Warm-Up

Why was the magnetic force stronger on Wednesday?

The spacecraft was moved closer to the launcher by the same amount Wednesday as it was on Tuesday, and yet its speed went up much more. Claim 3 suggests that the magnetic force was much stronger on Wednesday than on Tuesday.

Consider the two subclaims for Claim 3 and answer the question below.

> **Claim 3.A:** The magnetic force was much stronger on Wednesday **because the magnet was stronger.**
>
> **Claim 3.B:** The magnetic force was much stronger on Wednesday **because the magnetic force is stronger closer to the magnets.**

Which claim do you think is more convincing, and why?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Analyzing the Spacecraft Launches

Why did the model spacecraft go so much faster than expected on Wednesday?

Discuss with your partner to decide whether each piece of evidence supports or refutes a claim.

1. Discuss what the information on each card means.
2. Use the discussion questions below to help think about what you would expect to see in the evidence if each claim were true.
3. Place the question at the top of your desk. Place the two claims below the question, side by side. Decide which claim the evidence supports or refutes. Place each piece of evidence below the appropriate claim.
4. After you sort the evidence, answer the questions on the next two pages.

Discussion Questions

- What type of information does this card show?
- What information would you expect to see if Claim 3.A were true and the launcher magnet was stronger on Wednesday?
- What information would you expect to see if Claim 3.B were true and the force was much stronger when the magnets were closer together?

Name: _____ Date: _____

Analyzing the Spacecraft Launches (continued)

Use the evidence you have sorted to answer each question below and on the next page. You may choose more than one answer.

Which of the USA Evidence Cards support **Claim 2**: Much more energy was in the launcher system on Wednesday than on Tuesday. (choose all that apply)

- ☐ Card A
- ☐ Card B
- ☐ Card C
- ☐ Card D
- ☐ Card E
- ☐ None of the above

Which of the USA Evidence Cards support **Claim 3.A**: The magnetic force was much stronger on Wednesday **because the magnets were stronger.** (choose all that apply)

- ☐ Card A
- ☐ Card B
- ☐ Card C
- ☐ Card D
- ☐ Card E
- ☐ None of the above

Which of the USA Evidence Cards support **Claim 3.B**: The magnetic force was much stronger on Wednesday **because the magnetic force is stronger closer to the magnets.** (choose all that apply)

- ☐ Card A
- ☐ Card B
- ☐ Card C
- ☐ Card D
- ☐ Card E
- ☐ None of the above

Name: _____ Date: _____

Analyzing the Spacecraft Launches (continued)

Which of the claims did your evidence refute? (choose all that apply)

- ☐ **Claim 2**: Much more energy was in the launcher system on Wednesday than on Tuesday.
- ☐ **Claim 3.A**: The magnetic force was much stronger on Wednesday **because the magnets were stronger.**
- ☐ **Claim 3.B**: The magnetic force was much stronger on Wednesday **because the magnetic force is stronger closer to the magnets.**
- ☐ None of the above

Name: _____ Date: _____

Modeling the Spacecraft Launches

Complete the Modeling Tool activity: Spacecraft Launches on the next page.

Goal: Create models of the Tuesday and Wednesday spacecraft launches to explain the difference in speed.

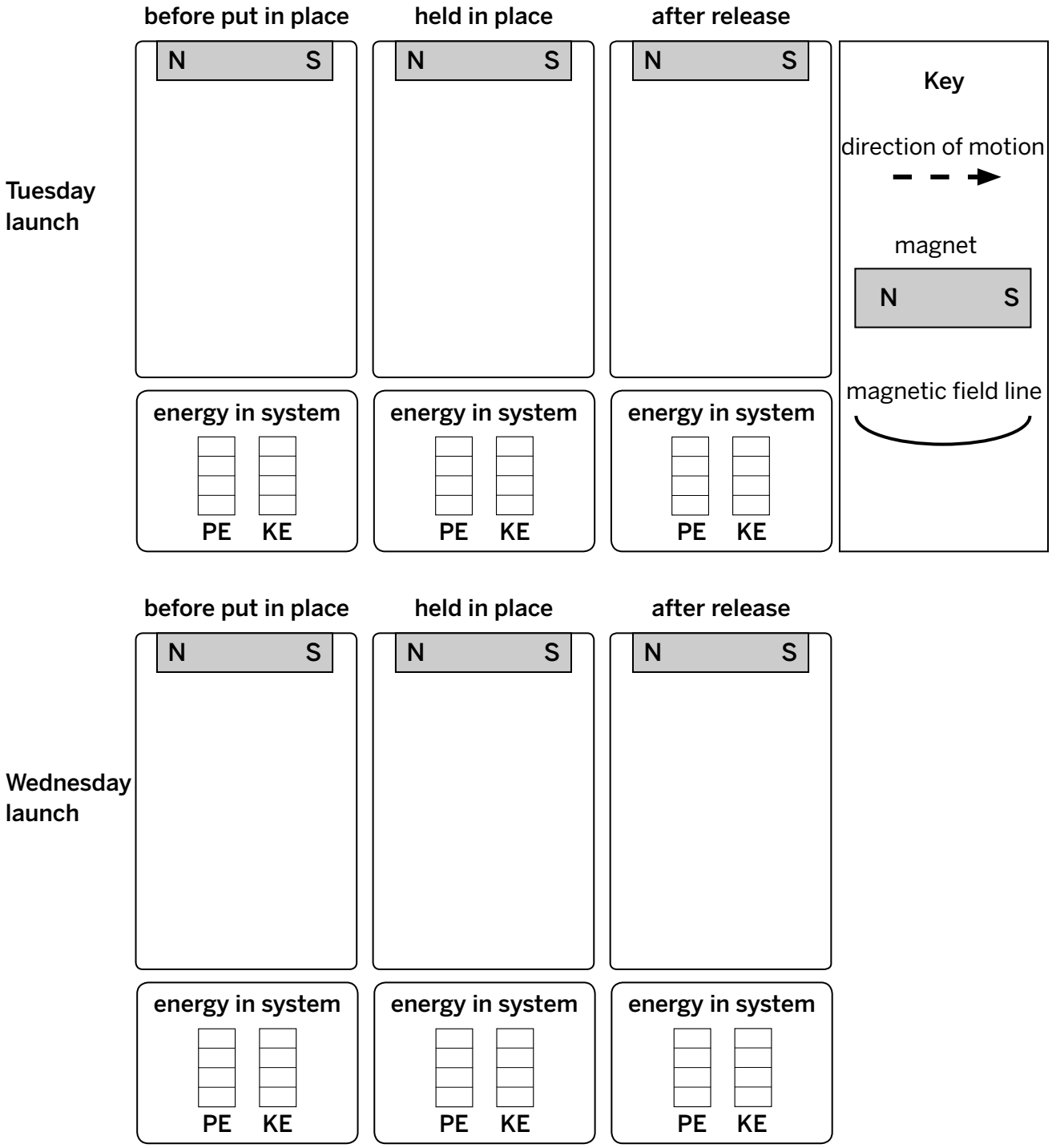
Do:

- In the "held in place" panel, show the starting position of the spacecraft.
- In the "after release" panel, show the motion of the spacecraft.
- Draw magnetic field lines in each panel.
- Annotate your models to show where the magnetic force is strongest.

Name: _____ Date: _____

Modeling Tool: Spacecraft Launches

Create models of the Tuesday and Wednesday spacecraft launches to explain the difference in speed. Use a magnet to represent the spacecraft in each launch. Use the symbols shown in the Key in your models.



Name: _____ Date: _____

Homework: Explaining the Spacecraft Launches

Write your final explanation to the Universal Space Agency. It may be helpful to review the USA Evidence Cards on pages 90–91 or refer to your Modeling Tool activity: Spacecraft Launches as you write.

Word Bank

convert	force	kinetic energy	magnetic field
magnetic pole	potential energy	system	transfer

Transition words and phrases

After	As a result of	Because	If . . ., then . . .
When	Since	Which means . . .	

Why did the model spacecraft go so much faster than expected on Wednesday?

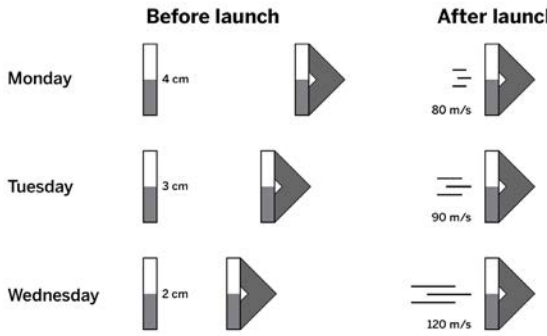
Name: _____ Date: _____

Homework: Explaining the Spacecraft Launches (continued)

Name: _____ Date: _____

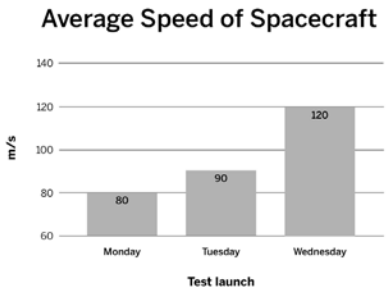
Homework: Explaining the Spacecraft Launches (continued)

Evidence Card A: Distance Between the Launcher and the Spacecraft in Each Launch



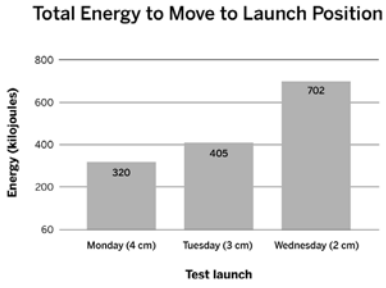
Evidence Card B: Average Speed of the Spacecraft When Launched

Test launch	Average speed of the spacecraft when launched	Increase from previous launch
Monday	80 m/s	----
Tuesday	90 m/s	10 m/s
Wednesday	120 m/s	30 m/s



Evidence Card C: Energy Used to Push Spacecraft to Final Position for Each Launch

The USA scientists calculated how much energy was used to push the spacecraft to each location during the setup process.

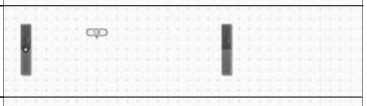


Name: _____ Date: _____

Homework: Explaining the Spacecraft Launches (continued)

Evidence Card D: Simulating the Launches

In the Simulation, the force got much stronger in each launch as the spacecraft magnet moved the same distance closer to the launcher magnet.

Modeled test launch	Strength sensor (milliteslas)	Arrangement of magnets
Monday	1.7	
Tuesday	1.9	
Wednesday	27.9	

Evidence Card E: Energy Used to Push Spacecraft to Initial Position for Each Launch

During the setup process of each launch, the USA scientists recorded how much energy was required to push the spacecraft to an initial position of 4 cm away from the launcher.

Launch date	Total energy to reach initial position 4 cm from launcher *(kilojoules)*
Monday	320
Tuesday	320
Wednesday	320

Name: _____ Date: _____

Lesson 3.5: Reviewing Key Ideas and Introducing Electromagnets

During our investigation of the spacecraft problem, we mentioned that the launcher magnets were *electromagnets.* In the upcoming Science Seminar in Chapter 4, you will be evaluating some roller coaster designs that also use electromagnets. But what are electromagnets? How are they different from permanent magnets? How do they work? Why are they useful? Let's go find out!

Unit Question

- Why do magnets move objects in different ways?

Chapter 3 Question

- Why was there so much more potential energy stored in the launcher system on Wednesday than on Tuesday?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.
- The pattern of magnetic field lines around attracting magnets is different from the pattern of magnetic field lines around repelling magnets.
- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.
- The energy used to move a magnet against a magnetic force is stored as potential energy in the magnetic field.
- Creating a model of a magnetic system and defining its parts helps scientists test and explain the relationship between force and energy.
- Moving a magnet against a stronger magnetic force transfers more energy to the magnetic field.
- A magnetic force is stronger closer to a magnet.

Name: _____ Date: _____

Lesson 3.5: Reviewing Key Ideas and Introducing Electromagnets
(continued)

Vocabulary

- attract
- electromagnet
- energy
- kinetic energy
- magnetic field
- magnetic pole
- potential energy
- repel
- system

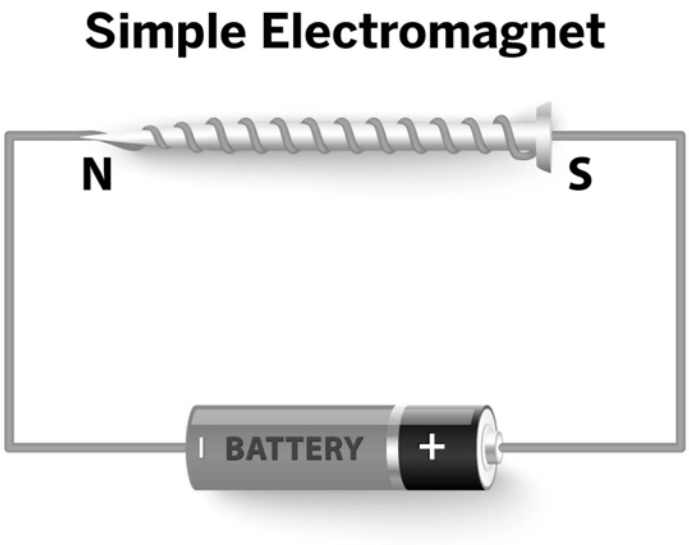
Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

As you watch the video, *How an Electromagnet Works,* make note of how electromagnets work and answer the questions below.



How are electromagnets similar to other magnets?

_____

_____

_____

_____

How are electromagnets different from other magnets?

_____

_____

_____

_____

Name: _____ Date: _____

Blue Group: Testing Electromagnets in the Sim

Part 1: Predictions About Potential Energy

Predict

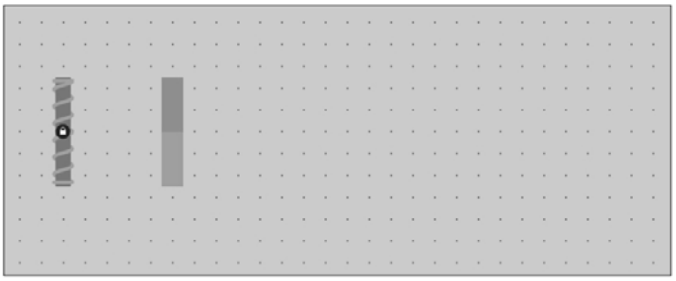
Which setup will have more potential energy? (circle one)

Setup 1 **Setup 2**

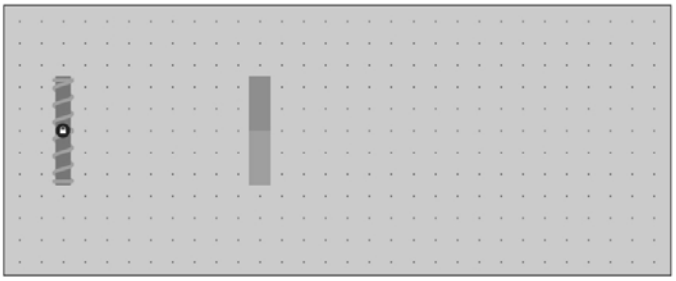
In which setup will the bar magnet have more kinetic energy when you press RUN in the Sim? (circle one)

Setup 1 **Setup 2**

Setup 1



Setup 2



Test

1. Launch the Magnetic Fields Simulation.
2. Switch to Electromagnets Mode and turn Field Lines on.
3. In Build, create Setup 1. Electromagnet A should be placed vertically and not rotated. Be sure to lock the electromagnet in place.
4. Record the amount of potential energy in the system.
5. Press RUN, then press ANALYZE.
6. Record the amount of kinetic energy in the system.
7. Press BUILD and repeat steps 3–6 with Setup 2.
8. Answer the question next to the data table on the next page.

Name: _____ Date: _____

Blue Group: Testing Electromagnets in the Sim (continued)

	Potential energy in Build	Kinetic energy in Run
Setup 1		
Setup 2		

Were your results the same as your predictions or different from your predictions? (check one)

- ☐ same
- ☐ different
- ☐ some of each

Part 2: Predictions About Force and Energy

Predict

Imagine moving the bar magnet three grid points closer to the electromagnet in each setup. In which setup will potential energy change more after the move? (circle one)

Setup 1 **Setup 2**

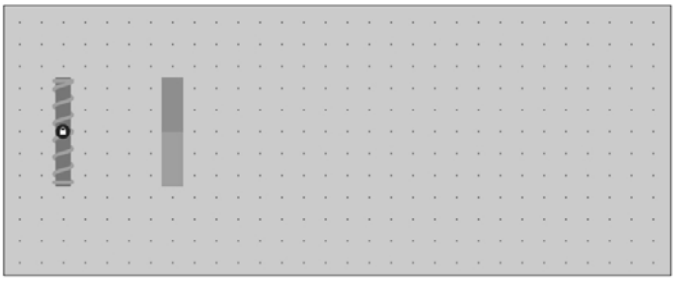
Explain your thinking.

_____

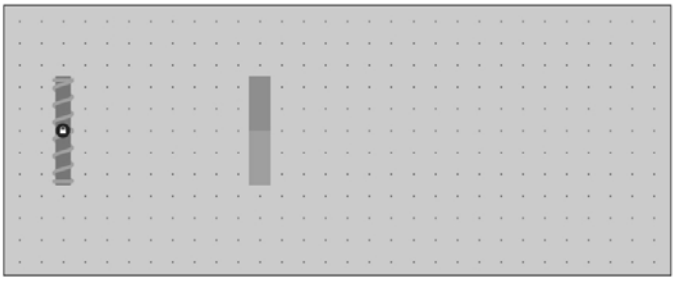
_____

_____

Setup 1



Setup 2



Name: _____ Date: _____

Blue Group: Testing Electromagnets in the Sim (continued)

Test

1. Launch the *Magnetic Fields* Simulation.
2. Switch to Electromagnets Mode and turn Field Lines on.
3. In Build, place the Electromagnet A as shown in both Setups. Electromagnet A should be placed vertically and not rotated. Be sure to lock the electromagnet in place.
4. Press RUN, then press ANALYZE.
5. Drag two SENSOR tools to determine force strength. Place one at five grid points from the electromagnet (the location where you will place the magnet in Setup 1). Place the second one at nine grid points from the electromagnet (the location where you will place the magnet in Setup 2). Record the values in the table below.
6. Return to Build and place the magnet as shown in Setup 1 (five grid points from the electromagnet). Record the potential energy in the data table.
7. Move the bar magnet three grid points closer to the electromagnet, and record the amount of potential energy after the move.
8. Calculate and record the change in potential energy.
9. Press BUILD and repeat steps 6–8 with Setup 2.
10. Answer the question below the data table.

	Force strength at magnet location (mT)	**Potential energy *before* move**	**Potential energy *after* move**	**Change in potential energy**
Setup 1 (five grid points away)				
Setup 2 (nine grid points away)				

Were your results the same as your predictions or different from your predictions? (check one)

- ☐ same
- ☐ different
- ☐ some of each

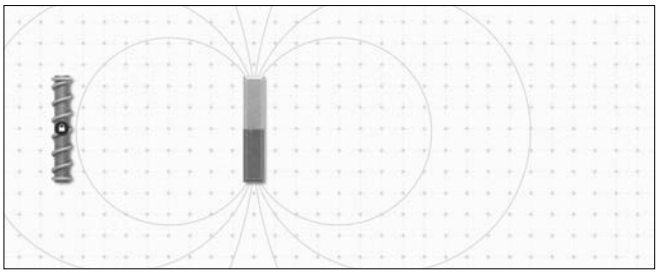
Name: _____ Date: _____

Blue Group: Making Explanations

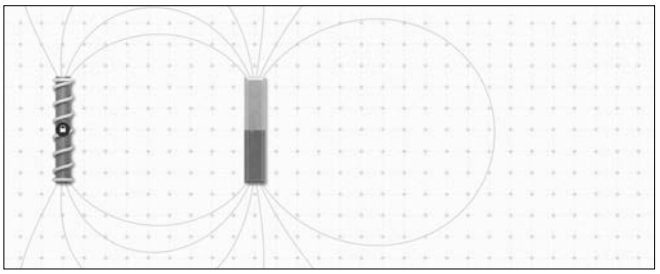
Part 1: Explaining Energy

The images below from the Sim show an electromagnet (locked in place) and a magnet, first with the electricity turned OFF and then with the electricity turned ON.

Electricity OFF



Electricity ON



Discuss the two images with your partner, then complete the statement.

Moving the magnet toward the electromagnet will transfer energy into the system if . . . (check one)

- ☐ the electricity is OFF.
- ☐ the electricity is ON.

Use the vocabulary in the Word Bank to complete the following explanation to support your answer.

Moving a magnet against a _____ transfers energy to the system of magnets, which is stored as _____ in the _____. If the magnet is released, the magnetic force will convert the _____ to _____ as the magnet moves.

Word Bank

potential energy	kinetic energy	magnetic force	magnetic field

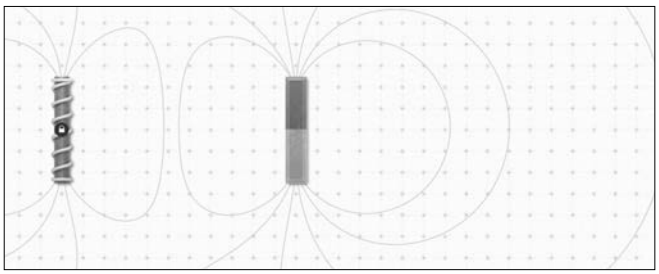
Name: _____ Date: _____

Blue Group: Making Explanations (continued)

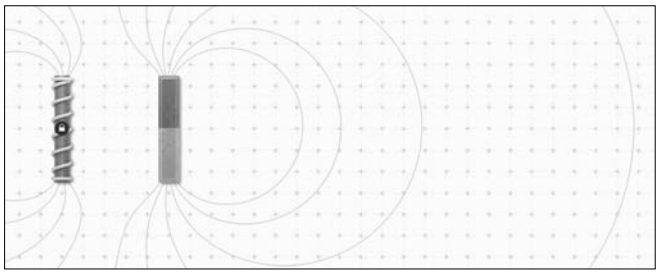
Part 2: Explaining Magnetic Force

The images below from the Sim show an electromagnet (locked in place) and a magnet about to be released.

Setup A



Setup B



Discuss Setups A and B with your partner, then answer the question.

Immediately after it is released, will the magnet move faster in Setup A or in Setup B? (check one)

- ☐ Setup A (magnets farther apart)
- ☐ Setup B (magnets closer together)

Use the vocabulary in the Word Bank to complete the following explanation to support your answer. Not all of the words will be used. Some words may be used more than once.

When the _____ is turned on, it will have a _____.

Moving a _____ against a _____ by placing it nearby transfers energy to the system of magnets, which is stored as _____ in the _____, and released as _____ when the magnet is allowed to move. Since _____ is stronger _____ a magnet, the magnet that is _____ the electromagnet when it is turned on will move faster.

Word Bank

potential energy	kinetic energy	magnetic force	magnetic field
magnet	electromagnet	closer to	farther from

Name: _____ Date: _____

Green Group: Testing Electromagnets in the Sim

Part 1: Predictions About Force and Energy

Predict

Imagine moving the bar magnet three grid points closer to the electromagnet in each setup. In which setup will potential energy change more after the move? (circle one)

Setup 1 **Setup 2**

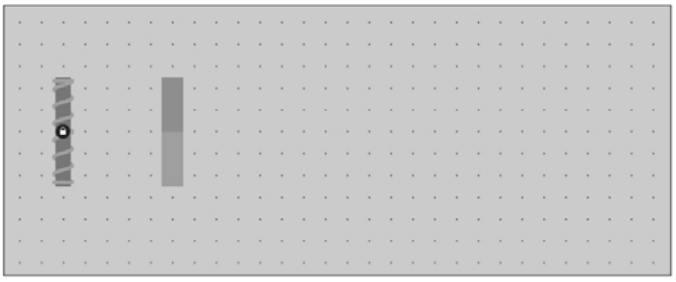
Explain your thinking.

_____

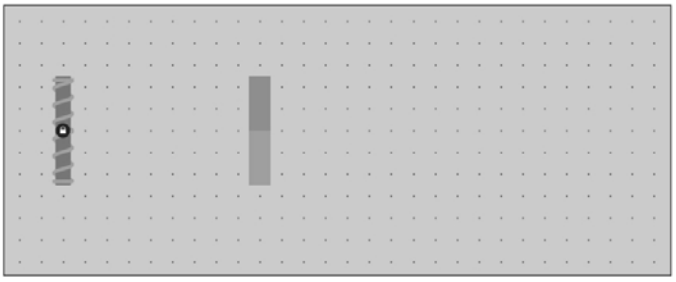
_____

_____

Setup 1



Setup 2



Name: _____ Date: _____

Green Group: Testing Electromagnets in the Sim (continued)

Test

1. Launch the *Magnetic Fields* Simulation.
2. Switch to Electromagnets Mode and turn Field Lines on.
3. In Build, place the Electromagnet A as shown in both Setups. Electromagnet A should be placed vertically and not rotated. Be sure to lock the electromagnet in place.
4. Press RUN, then press ANALYZE.
5. Drag two SENSOR tools to determine force strength. Place one at five grid points from the electromagnet (the location where you will place the magnet in Setup 1). Place the second one at nine grid points from the electromagnet (the location where you will place the magnet in Setup 2). Record the values in the table below.
6. Return to Build and place the magnet as shown in Setup 1 (five grid points from the electromagnet). Record the potential energy in the data table.
7. Move the bar magnet three grid points closer to the electromagnet, and record the amount of potential energy after the move.
8. Calculate and record the change in potential energy.
9. Press BUILD and repeat steps 6–8 with Setup 2.
10. Answer the question below the data table.

	Force strength at magnet location (mT)	**Potential energy *before* move**	**Potential energy *after* move**	**Change in potential energy**
Setup 1 (five grid points away)				
Setup 2 (nine grid points away)				

Were your results the same as your predictions or different from your predictions? (check one)

- ☐ same
- ☐ different
- ☐ some of each

Name: _____ Date: _____

Green Group: Testing Electromagnets in the Sim (continued)

Part 2: Predictions About Iron

Predict

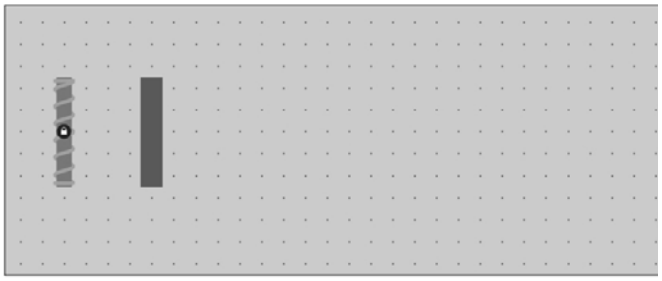
In **Setup 1,** the iron will move . . .

- ☐ **toward** the electromagnet.
- ☐ **away from** the electromagnet.

In **Setup 2,** the iron will move . . .

- ☐ **toward** the electromagnet.
- ☐ **away from** the electromagnet.

Setup 1



Setup 2

How can you make the potential energy as high as possible in a magnetic field between one electromagnet and one piece of iron?

_____

_____

_____

Name: _____ Date: _____

Green Group: Testing Electromagnets in the Sim (continued)

Test

1. Launch the *Magnetic Fields* Simulation.
2. Switch to Electromagnets Mode and turn Field Lines on.
3. In Build, create Setup 1. Electromagnet A should be placed vertically and not rotated.
4. Lock the electromagnet in place.
5. Press RUN and observe the movement of the iron. Record your observation in the table below.
6. Press BUILD. Try to make the potential energy as high as possible in the magnetic field. Record your methods in the table below
7. To create Setup 2, remove the lock from the electromagnet, then rotate the electromagnet twice in the same direction to reverse the poles.
8. Repeat steps 4–6 for Setup 2.
9. Answer the question below.

	Did iron move toward or away from the electromagnet?	**What did you do to make potential energy as high as possible in the magnetic field?**
Setup 1		
Setup 2		

Were your results the same as your predictions or different from your predictions? (check one)

- ☐ same
- ☐ different
- ☐ some of each

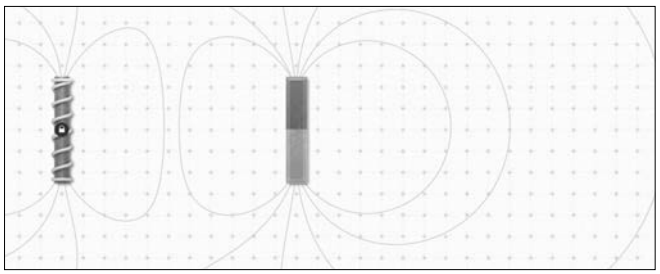
Name: _____ Date: _____

Green Group: Making Explanations

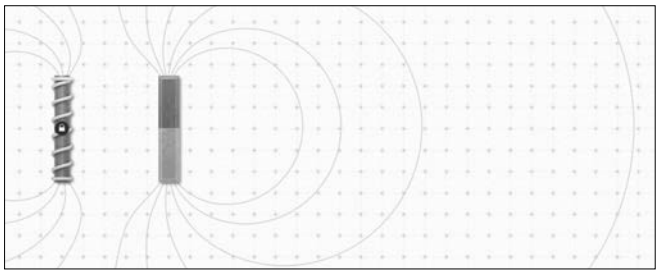
Part 2: Explaining Magnetic Force

This images below from the Sim show an electromagnet (locked in place) and a magnet about to be released.

Setup A



Setup B



Discuss Setups A and B with your partner, then answer the question.

Immediately after it is released, will the magnet move faster in Setup A or in Setup B? (check one)

- ☐ Setup A (magnets farther apart)
- ☐ Setup B (magnets closer together)

Use the vocabulary in the Word Bank to complete the following explanation to support your answer. Not all of the words will be used. Some words may be used more than once.

When the _____ is turned on, it will have a _____.

Moving a _____ against a _____ by placing it nearby transfers energy to the system of magnets, which is stored as _____ in the _____, and released as _____ when the magnet is allowed to move. Since _____ is stronger _____ a magnet, the magnet that is _____ the electromagnet when it is turned on will move faster.

Word Bank

potential energy	kinetic energy	magnetic force	magnetic field
magnet	electromagnet	closer to	farther from

Name: _____ Date: _____

Purple Group: Testing Electromagnets in the Sim

Part 1: Predictions About Iron

Predict

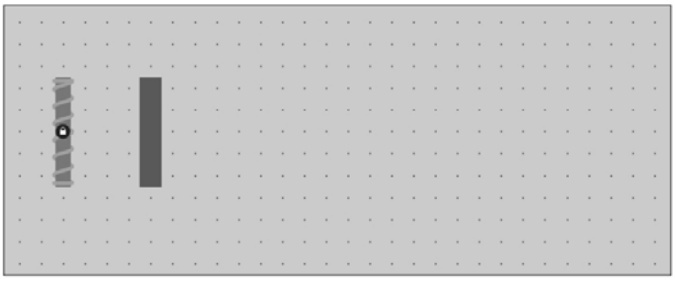
In **Setup 1,** the iron will move . . .

- ☐ **toward** the electromagnet.
- ☐ **away from** the electromagnet.

In **Setup 2,** the iron will move . . .

- ☐ **toward** the electromagnet.
- ☐ **away from** the electromagnet.

Setup 1



Setup 2

How can you make the potential energy as high as possible in a magnetic field between one electromagnet and one piece of iron?

_____

_____

_____

Name: _____ Date: _____

Purple Group: Testing Electromagnets in the Sim (continued)

Test

1. Launch the *Magnetic Fields* Simulation.
2. Switch to Electromagnets Mode and turn Field Lines on.
3. In Build, create Setup 1. Electromagnet A should be placed vertically and not rotated.
4. Lock the electromagnet in place.
5. Press RUN and observe the movement of the iron. Record your observation in the table below.
6. Press BUILD. Try to make the potential energy as high as possible in the magnetic field. Record your methods in the table below
7. To create Setup 2, remove the lock from the electromagnet, then rotate the electromagnet twice in the same direction to reverse the poles.
8. Repeat steps 4–6 for Setup 2.
9. Answer the question below.

	Did iron move toward or away from the electromagnet?	**What did you do to make potential energy as high as possible in the magnetic field?**
Setup 1		
Setup 2		

Were your results the same as your predictions or different from your predictions? (check one)

- ☐ same
- ☐ different
- ☐ some of each

Name: _____ Date: _____

Purple Group: Making Explanations

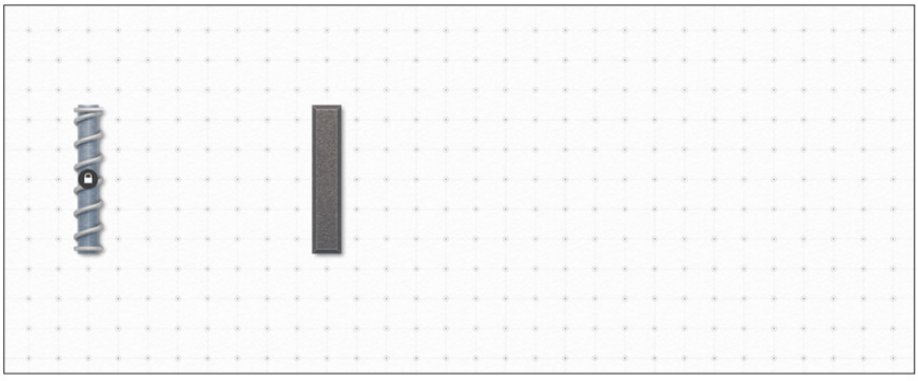
Reading About Magnets and Iron

1. Read the short article below and discuss it with your partner.

   If you place a piece of iron near a magnet, the magnet will attract the iron. Why does this happen? Strong magnetic fields can create new magnetic fields in some materials, including iron. When the iron is inside a magnetic field, the field creates a north pole and a south pole in the iron. The magnetic poles in the iron align with the poles of the magnet so that the iron and magnet attract. These new poles are temporary, however: if you move the iron away from the magnet, the iron quickly becomes a non-magnet again.

2. Discuss the Electromagnet and Iron setup in the image from the Sim with your partner, then answer the question below.

Electromagnet and Iron



There is a piece of iron near a locked electromagnet, with the electricity turned OFF. What will happen to the piece of iron when the electricity is turned ON? Why?

_____

_____

_____

Name: _____ Date: _____

Purple Group: Making Explanations (continued)

3. Use the vocabulary in the Word Bank to explain why a magnet will never repel a piece of iron.

Word Bank

magnetic field	magnetic force	magnetic pole	potential energy	kinetic energy

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below and on the next page.

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the model spacecraft went so much faster than expected on Wednesday?

1. I understand how the launcher can make the model spacecraft move without touching it. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. I understand where the energy to launch the model spacecraft came from. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

3. I understand how force caused different amounts of potential energy to be stored in the launcher system. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand how potential and kinetic energy changed during the spacecraft launches. (check one).

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

5. What do you still wonder about the magnetic spacecraft launcher?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Chapter 4: Designing Roller Coasters
Chapter Overview

Fellow student physicists were impressed by your work in solving the spacecraft problem. They have called upon you to help them with their problem: how to design the best electromagnetic rollercoaster. By analyzing evidence and discussing the competing claims with your class, you will decide which design will launch a roller coaster car the fastest.

Name: _____ Date: _____

Lesson 4.1: Evaluating Roller Coaster Experiments

What is the best design for an electromagnetic roller coaster with maximum speed? You've been asked by three students to help decide which of their electromagnet roller coaster designs would launch a roller coaster car the fastest. To help decide which design they should submit for a physics contest, you'll need to use everything you learned while solving the spacecraft launcher problem.

Unit Question

- Why do magnets move objects in different ways?

Chapter 4 Question

- Which design will launch the roller coaster car the fastest?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.
- The pattern of magnetic field lines around attracting magnets is different from the pattern of magnetic field lines around repelling magnets.
- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.
- The energy used to move a magnet against a magnetic force is stored as potential energy in the magnetic field.
- Creating a model of a magnetic system and defining its parts helps scientists test and explain the relationship between force and energy.
- Moving a magnet against a stronger magnetic force transfers more energy to the magnetic field.
- A magnetic force is stronger closer to a magnet.

Vocabulary

- attract
- convert
- electromagnet
- energy
- isolate
- kinetic energy
- magnetic field
- magnetic field lines
- magnetic pole
- potential energy
- repel
- system
- transfer
- variable

Name: _____ Date: _____

Warm-Up

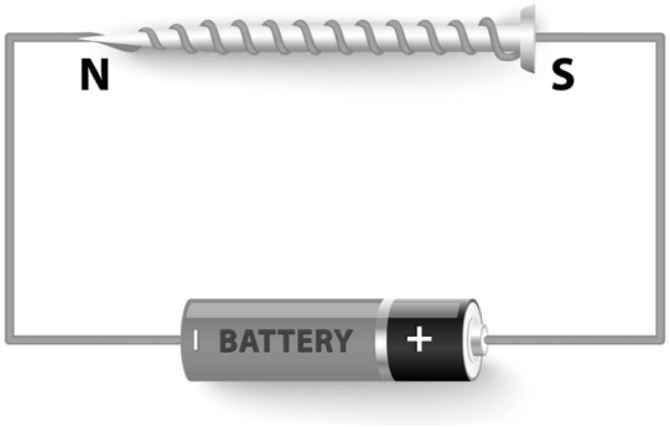
Read the short article below and answer the questions. Then, discuss your answers with your partner.

Electromagnets

An electromagnet can be created using a battery, some wire, and an iron nail. The wire is coiled around the nail a bunch of times and then connected to a battery. When the electric current from the battery runs through the wire, suddenly the nail will repel or attract magnets!

Running electric current through the wire creates a magnetic field around the wire-coiled nail. If you turn the electricity up, the magnetic field gets stronger. If you turn it off, the magnetic field will no longer exist. If you change the direction that the electricity flows in through the wire, you can even reverse the poles of the magnetic field!

Simple Electromagnet



What might be some advantages of using electromagnets instead of permanent magnets?

_____

_____

_____

How are electromagnets made?

_____

_____

_____

Name: _____ Date: _____

Annotating Competing Designs

- Closely examine and annotate each design to record your observations and questions.
- Note the ways that the designs are different and record your ideas about how the differences will affect the speed of the roller coaster car.
- Think about the key concepts you learned while investigating the spacecraft problem, which are posted on the classroom wall.

After you have considered and annotated each design, discuss the following question with your partner:

- Which design do you think will launch the roller coaster car the fastest?

This is your initial thinking. It is okay if you are unsure.

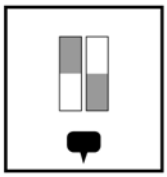
Name: _____ Date: _____

Evaluating Experiments

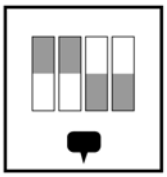
Evidence Card E: What is the effect of the arrangement of magnetic poles?

Experiment Description

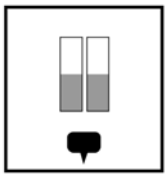
- Three different arrangements of magnets were made.
- Two of these arrangements had two magnets; the other one had four magnets.
- A sensor to measure magnetic force was placed 1 cm from each set of magnets.



sensor reading: 0.9 mT



sensor reading: 4.3 mT



sensor reading: 1.9 mT

Is the test variable isolated?

1. What variable was being tested?
2. How were the effects measured?
3. Which test variables were changed and which stayed the same?
4. Can you conclude that the differences in the results are due to the effect of the test variable?

For each evidence card, determine:

- What variable was tested?
- How were the effects measured?
- Which variables were changed and which stayed the same in the tests?
- Can you conclude that the differences in results are due to the effect of the test variable?

Select which evidence can be eliminated because it did not isolate variables. (check all that apply)

- ☐ Evidence Card A: Magnetic pole arrangement
- ☐ Evidence Card B: Number of wire coils
- ☐ Evidence Card C: Rail material
- ☐ Evidence Card D: Distance between the car and launcher
- ☐ None should be eliminated.

Name: _____ Date: _____

Lesson 4.2: Evaluating Roller Coaster Design Claims

Which design will launch the roller coaster car the fastest? In the previous lesson, you discarded evidence from experiments that did not isolate variables. Today, you will be able to gather new evidence about these variables and then analyze all of the reliable evidence. Which of the variables do you think is the most important? Who has the best design?

Unit Question

- Why do magnets move objects in different ways?

Chapter 4 Question

- Which design will launch the roller coaster car the fastest?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.
- The pattern of magnetic field lines around attracting magnets is different from the pattern of magnetic field lines around repelling magnets.
- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.
- The energy used to move a magnet against a magnetic force is stored as potential energy in the magnetic field.
- Creating a model of a magnetic system and defining its parts helps scientists test and explain the relationship between force and energy.
- Moving a magnet against a stronger magnetic force transfers more energy to the magnetic field.
- A magnetic force is stronger closer to a magnet.

Name: _____ Date: _____

Lesson 4.2: Evaluating Roller Coaster Design Claims (continued)

Vocabulary

- attract
- convert
- electromagnet
- energy
- isolate
- kinetic energy
- magnetic field
- magnetic field lines
- magnetic pole
- potential energy
- repel
- system
- transfer
- variable

Digital Tools

- *Magnetic Fields* Simulation

Name: _____ Date: _____

Warm-Up

In the previous lesson, you evaluated which experiments provided the strongest evidence about the roller coaster designs. The experiments recorded on Card B and Card D did not isolate variables, so they were eliminated.

Today, you will use the *Magnetic Fields* Simulation to collect more reliable data about the two variables that were tested on the eliminated cards: the number of wire coils on the electromagnet and the distance between the car and launcher.

1. How does the number of wire coils on an electromagnet affect the strength of magnetic force?

Describe how you will set up tests with isolated variables in the Sim to answer this question.

What will you change?

_____

_____

What will you keep the same?

_____

_____

What will you measure?

_____

_____

Name: _____ Date: _____

Warm-Up (continued)

2. How does the distance between the car and launcher affect the speed of the car?

Describe how you will set up tests with isolated variables in the Sim to answer this question.

What will you change?

_____

_____

What will you keep the same?

_____

_____

What will you measure?

_____

_____

Name: _____ Date: _____

Testing Roller Coaster Variables

Refer to the Warm-Up as you finalize a plan with your partner for conducting experiments in the Sim. Your goal is to gather reliable data about the effects of two variables: different numbers of coils on the electromagnet, and different distances between the car and launcher.

Launch the *Magnetic Fields* Simulation and begin your experiments.

Remember to:

- Lock electromagnets in place
- Isolate your variables to be sure your conclusions make sense

Complete Evidence Cards F and G as you collect your data.

Name: _____ Date: _____

Analyzing Roller Coaster Evidence

Determine what the data on each card means.

1. Review your annotations from the last lesson about the quality of the experimental evidence on each evidence card.
2. Shift your focus to the **results** of the experiments on the other side of the cards.
3. Annotate each of the remaining evidence cards (A and C) and your new evidence cards (F and G), thinking carefully about what the results tell you about roller coaster design. You may want to consider these questions:
   - Which variable was being tested?
   - Did changing this variable seem to have a big or small effect on the launch speed?
   - What does the result say about how the variable affects the launch speed?

Name: _____ Date: _____

Evaluating Roller Coaster Designs

Decide which evidence cards support each claim.

1. Lay the design claims at the top of your desk, side by side.
2. Discuss each evidence card (A, C, F, G) with your partner, using the following questions:
   - What is the effect of the variable tested on launch speed?
   - Which of the four variables has the greatest effect on the launch speed?
3. Place each evidence card under the design claim you feel it supports or goes against. If you are unsure, you can place the card off to the side.
   - If the evidence supports a design claim, write "Supports (Christina's, Nevi's, or Dorian's) design" on that card.
   - If the evidence refutes a design claim, write "Goes against (Christina's, Nevi's, or Dorian's) design" on that card.
   - If the evidence connects with another evidence card, write "Connects with Evidence Card (A, C, F, or G)" on that card.
4. Decide which design claim is best supported by the available evidence.
5. When you and your partner are satisfied with your evidence card sorts and the design claim you have chosen, respond to the questions:

Based on all the evidence you have seen, which design do you think will launch the roller coaster car the fastest? (check one)

- ☐ Christina's design
- ☐ Nevi's design
- ☐ Dorian's design

Explain your choice. What evidence suggests that this design will launch the roller coaster car the fastest?

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 4.3: The Science Seminar

Which design will launch the roller coaster car the fastest? In today's Science Seminar, you and your classmates will discuss the evidence, listen to one another's ideas, and try to arrive at an understanding of what is most important when designing an electromagnetic roller coaster. After hearing your classmates and participating in the discussion, you will be ready to write a convincing scientific argument.

Unit Question

- Why do magnets move objects in different ways?

Chapter 4 Question

- Which design will launch the roller coaster car the fastest?

Key Concepts

- A magnetic force can attract or repel an object at a distance.
- In a system of magnets, there is a repelling force between like poles and an attracting force between opposite poles.
- The pattern of magnetic field lines around attracting magnets is different from the pattern of magnetic field lines around repelling magnets.
- A magnetic force can convert potential energy stored in a magnetic field to kinetic energy.
- The energy used to move a magnet against a magnetic force is stored as potential energy in the magnetic field.
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- Moving a magnet against a stronger magnetic force transfers more energy to the magnetic field.
- A magnetic force is stronger closer to a magnet.

Vocabulary

- attract
- convert
- electromagnet
- energy
- isolate
- kinetic energy
- magnetic field
- magnetic field lines
- magnetic pole
- potential energy
- repel
- system
- transfer
- variable

Name: _____ Date: _____

Warm-Up

In today's Science Seminar, you and your classmates will discuss the evidence, listen to one another's ideas, and try to arrive at the best understanding of what is important when designing an electromagnetic roller coaster.

Review the design claims, evidence cards, and the roller coaster design you wrote about in the last lesson. If needed, revise your writing below.

Explain your choice. What evidence suggests that this design will launch the roller coaster car the fastest?

_____

_____

_____

_____

_____

_____

Identify one evidence card that is the most convincing piece of evidence. Draw a star on that evidence card.

Name: _____ Date: _____

Preparing for the Science Seminar

1. Take turns with your partner sharing which design you think will launch the roller coaster car the fastest.
2. Use your Warm-Up response and starred evidence card to help you share ideas.
3. Use the Argumentation Sentence Starters on the scientific argumentation wall to help you respond to your partner's ideas.
4. Refer to the design claims and evidence cards as needed.

Which design will launch the roller coaster car the fastest?

- Christina's Design
- Nevi's Design
- Dorian's Design

Argumentation Sentence Starters

- I think this evidence supports this claim because . . .
- I don't think this evidence supports this claim because . . .
- I agree because . . .
- I disagree because . . .
- Why do you think that?

Name: _____ Date: _____

Science Seminar Observations

Write a check mark in the right-hand column every time you hear one of your peers say or do something listed in the left-hand column. If you hear an interesting idea, write it in the last row of the table.

Observations during the seminar	**Check marks**
I heard a student use evidence to support a claim.	
I heard a student respectfully disagree with someone else's thinking.	
I heard a student explain how her evidence is connected to her claim.	
I heard a student evaluate the quality of evidence.	
I heard an idea that makes me better understand one of the claims. That idea is:	

Name: _____ Date: _____

Homework: Writing a Scientific Argument

Write an argument to answer the question *Which design will launch the roller coaster car the fastest?*

Getting Ready to Write

A. Choose one of the three design claims below.

- ☐ Christina's design will launch the roller coaster the fastest.
- ☐ Nevi's design will launch the roller coaster the fastest.
- ☐ Dorian's design will launch the roller coaster the fastest.

B. Next, choose all the evidence that supports your argument. You may look back at your evidence cards.

- ☐ Evidence Card A: Magnetic Pole Arrangement
- ☐ Evidence Card C: Rail Material
- ☐ Evidence Card F: Number of Wire Coils
- ☐ Evidence Card G: Distance Between the Car and Launcher

Write Your Argument

C. Now you are ready to write your argument. Be sure to

1. include the design claim (from Step A) that you think is strongest,
2. describe the force that launches the car forward,
3. use evidence (from Step B) to support your thinking and explain why you think the design claim you chose is the strongest, and
4. refer to the Scientific Argument Sentence Starters for help in constructing your argument.

Scientific Argument Sentence Starters	
Describing evidence:	**Describing how the evidence supports the claim:**
The evidence that supports my claim is . . .	If _____, then . . .
My first piece of evidence is . . .	This is important because . . .
Another piece of evidence is . . .	Since . . .
This evidence shows that . . .	Based on the evidence, I conclude that . . .
	This claim is stronger because . . .

Name: _____ Date: _____

Homework: Writing a Scientific Argument (continued)

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

1. I understand that evidence is stronger when the variable being tested is isolated, so only one variable is changed at a time. (check one)

   ☐ yes

   ☐ not yet

Explain your answer choice.

_____

_____

2. What are the most important things you learned in this unit about why magnets move objects in different ways?

_____

_____

_____

_____

_____

3. What questions do you still have?

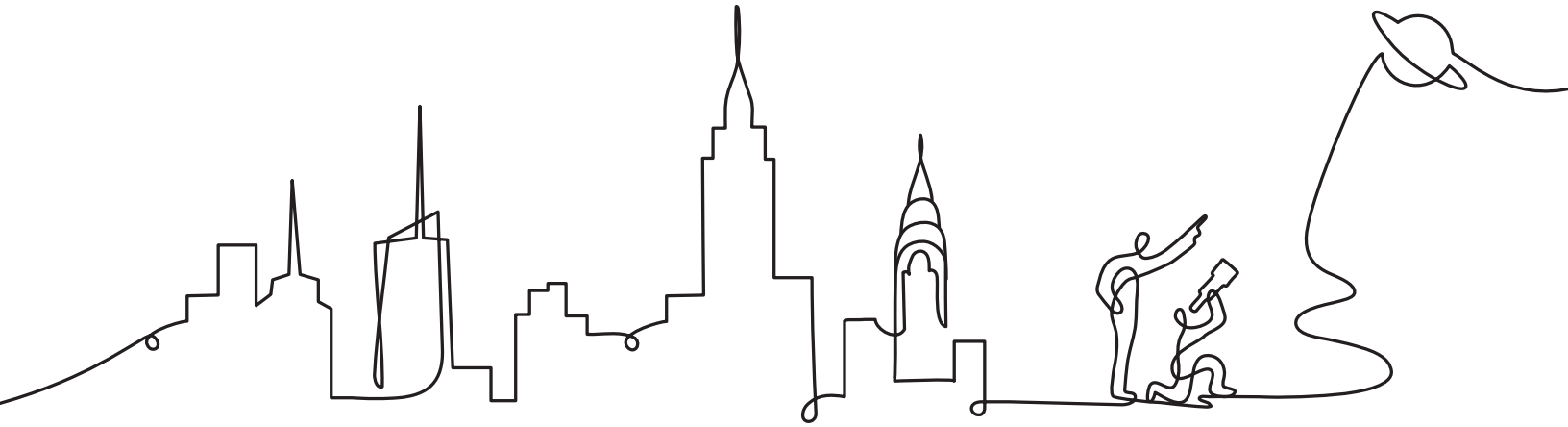
_____

_____

_____

_____

_____



New York City Companion Lesson

Name: _____ Date: _____

Water Wheel Design

Part 1: Preparing to Record Data

1. What is your design criterion?

_____

_____

2. How will you be able to tell which group's washer had the greatest increase in potential energy (stored the most energy)?

_____

_____

_____

3. What data do you need to record to determine if your water wheel meets the design criterion?

_____

_____

_____

4. What data do you need to record to determine which group's washer had the greatest increase in potential energy (stored the most energy)?

_____

_____

_____

Name: _____ Date: _____

Water Wheel Design (continued)

Part 2: Recording and Analyzing Data from Water Wheel Tests

Create a table to record data that will help you determine:

- whether or not your water wheel met the design criterion.
- which group's washer had the greatest increase in potential energy.

5. Did your team's water wheel meet the design criterion? What is your evidence?

_____

_____

_____

_____

Name: _____ Date: _____

Water Wheel Design (continued)

6. Where did the energy come from that eventually led to the washer being lifted?

_____

_____

_____

_____

7. Which group's washer had the greatest increase in potential energy? How can you tell?

_____

_____

_____

_____

Name: _____ Date: _____

Water Wheel Design (continued)

Part 3: Applying Ideas

Celia tries to push a heavy box up a hill. She pushes and pushes but the box does not move. Her brother and sister come to help her. Her brother, Ray, is able to push the box 2 meters up the hill. Her sister, Lana, is able to push the box 5 meters up the hill.

8. Who was able to change the energy of the box? Check all that are correct.

- ☐ Celia
- ☐ Ray
- ☐ Lana

Explain your answer.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Water Wheel Design (continued)

9. Who was able to do work on the box? Check all that are correct.

- ☐ Celia
- ☐ Ray
- ☐ Lana

Explain your answer.

_____

_____

_____

_____

_____

_____

10. Who was able to do the most work on the box? Check one.

- ☐ Celia
- ☐ Ray
- ☐ Lana

Explain your answer.

_____

_____

_____

_____

_____

_____

Magnetic Fields Glossary

attract: to pull objects toward one another

atraer: jalar los objetos unos a otros

convert: to change from one type to another

convertir: cambiar de un tipo a otro

electromagnet: a type of magnet in which the magnetic field is produced by an electric current

electroimán: un tipo de imán en el que el campo magnético es producido por una corriente eléctrica

energy: the ability to make things move or change

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

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

isolate: to separate or set apart

aislar: separar o apartar

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 field: the space around a magnet in which magnetic forces can act on objects

campo magnético: el espacio que rodea a un imán, en el cual las fuerzas magnéticas pueden actuar sobre los objetos

magnetic field line: a line that connects opposite magnetic poles and represents the strength and direction of the magnetic field

línea de campo magnético: una línea que conecta polos magnéticos opuestos y que representa la fuerza y la dirección del campo magnético

magnetic pole: one of the two opposite ends of a magnet

polo magnético: uno de los dos extremos opuestos de un imán

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

refute: to provide evidence that goes against a claim
refutar: proporcionar evidencia en contra de una afirmación

repel: to push objects away from each other
repeler: empujar los objetos alejándose unos de otros

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

variable: something that can be changed and may be measured
variable: algo que se puede cambiar y que se puede medir

work: the measure of the energy that is transferred when a force is applied to an object and that object travels some distance
trabajo: una medida de la energía que es

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