What Is Scientific Measurement?

What would happen if every scientist used different measurements? In this activity, you will explore why a standard system of measurement is important.

**INQUIRY FOCUS Measure**

**Procedure**

1. With your group, choose a small object to use as a unit of measure. For example, you might use one student’s thumb or an eraser.

2. Use a straight edge to draw a straight line on the back of this paper. Measure the length of the line using the unit of measure you selected in Step 1. Record the length below including your unit of measure, such as “10 thumbs.” Do not provide any other details about your unit of measure.

   Length:

3. Use a metric ruler to find the length of your line in centimeters. Round to the nearest tenth of a centimeter. Record the length below.

   Length:

4. On a separate piece of paper, write down the length of your line from Step 2. Trade the paper with another group. Then draw a line according to the units listed on their paper. Return the paper to the other group.

5. Trade your paper again with a different group. Repeat Step 4 and record the measurement. Return the paper to the group.

6. Use a ruler to measure the lines your classmates made using your units. Compare the results your classmates got with your original measurements.

**Think It Over**

1. Which measurement was closest to your original measurement?

2. Why do you think scientists use standard measurements?
Measuring With SI

The basic SI unit for measuring length is the meter. In this activity, you will use a meter stick to measure objects in your classroom.

**INQUIRY FOCUS Measure**

**Procedure**

1. **With your partner, decide on ten objects to measure, including the length of the classroom. Record your choices in the data table.**

2. **Use the meter stick to measure each object. Record your measurements in the Length column of the data table.**

3. **Convert each measurement you made into millimeters (mm). Record those values in the data table.**

<table>
<thead>
<tr>
<th>Object</th>
<th>Length</th>
<th>Length in mm</th>
<th>Object</th>
<th>Length</th>
<th>Length in mm</th>
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</tbody>
</table>

**Think It Over**

1. Were your measurements accurate? How could you make them more accurate?

2. Suppose a team of students measured the length of the classroom five times, and the measurement was exactly the same each time. Can you tell if their work was both accurate and precise? If not, explain what else you would need to know.
A Unit of SI

Density is a measure of how much mass is contained in a given volume. In this activity, you will find the density of an irregular solid.

**INQUIRY FOCUS Measure, Calculate**

**Procedure**

1. Use the balance to measure the rock’s mass. Record your measurement in the data table for Trial 1.

2. Pour 50 mL of water into a graduated cylinder. Record the starting volume in the data table.

3. Gently slide the rock into the water. Measure the volume of the rock plus the water. Record the result.

4. Subtract the original volume of water in the graduated cylinder from the volume you found in Step 3. The result is the volume of the rock. Record your result.

5. To calculate the density of the rock, divide its mass by its volume. Record the result.

6. Repeat Steps 1 through 5 and record your data for Trial 2.

**Materials**

- small rock
- 100-mL graduated cylinder
- balance
- tap water

**Measurements and Calculations**

<table>
<thead>
<tr>
<th>Step</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mass of object (g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Volume of water (mL)</td>
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<td></td>
</tr>
<tr>
<td>3. Volume of water plus rock (mL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Volume of rock (cm³)</td>
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<td></td>
</tr>
<tr>
<td>5. Density of rock (g/cm³)</td>
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</tbody>
</table>

**Think It Over**

1. When you put the rock into the water, the volume in the graduated cylinder changed. Would the change in volume be different for different objects? Why?

2. Why did you repeat your measurements?
How Do Math and Science Work Together?

Estimating, calculating, and finding averages are just a few of the math skills that scientists use on a regular basis. How have you used math in science? In this activity, you will explore one way that scientists can use math.

INQUIRY FOCUS Calculate

**Procedure**

1. Use the balance to find the mass of one crayon to the nearest tenth of a gram. Record the mass below.

   Mass: ____________________________

2. Predict the mass of all the crayons, not including the box. Write your prediction below.

   Prediction: ____________________________

3. Use the balance to find the total mass of the crayons. Compare the result to your prediction.

**Think It Over**

1. Explain how you made your prediction. What math skills did you use?

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

2. What are some possible sources of error in your prediction? What math skills could you use to reduce the error?

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

**Materials**

- triple-beam balance
- used box of crayons
Is It Accurate?

When scientists make measurements, they try to be as precise and accurate as possible. To ensure precision and accuracy, they measure more than once. In this activity, you will make measurements of the mass of a laboratory flask and then judge how precise and accurate your measurements were.

INQUIRY FOCUS Measure, Evaluate Data Reliability

Procedure

1. Use the laboratory balance to measure the mass of a flask. Record your measurement in the data table and remove the flask from the balance after each trial. Measure the mass six times.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mass</th>
<th>Trial</th>
<th>Mass</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>4</td>
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<td>5</td>
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<tr>
<td>3</td>
<td></td>
<td>6</td>
<td></td>
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</tbody>
</table>

2. After your teacher provides you with the mass he or she measured for the flask, compare your measurements with the teacher’s measurements.

Think It Over

1. How many significant figures did you use in your measurements? Explain why.

2. Were your measurements both precise and accurate? Explain.

3. If your measurements were not precise, what could you do or change in order to make them more precise?
Math Tools in Science

When scientists measure something that has a known value, they can calculate the percent error of their measurement to determine how accurate it is. In this activity, you will measure the density of a substance with a known density. Then, you will calculate the percent error of your measurement.

INQUIRY FOCUS Measure, Calculate

Procedure

1. Use the balance to find the mass of the piece of copper. Make a data table on the back of this sheet, and record the mass of the copper in the table.

2. Add about 50 mL of water to the graduated cylinder. Read the exact volume of the water in mL, and record it in the data table.

3. Gently slide the piece of copper into the graduated cylinder without spilling any water. Read the volume of the water and copper together. Record this volume in the data table.

4. Discuss with your partner how you would determine the volume of the piece of copper. Calculate the volume of the copper, and record that value.

5. Calculate the density of the copper by dividing its mass by its volume. Record the density in the data table.

Think It Over

The true value of the density of copper is 8.92 g/mL. Calculate the percent error of your measurement of density using this formula:

\[
\text{Percent Error} = \left( \frac{\text{experimental value g/mL} - \text{true value g/mL}}{\text{true value g/mL}} \right) \times 100\%
\]

What is the percent error of your measurement of the density of copper?

Based on the percent error, do you think your measurement is accurate? Explain.
What’s in a Graph?

Graphs help scientists analyze data and draw conclusions by showing information rather than explaining it in words. In this activity, you will collect data about your classmates and show your results in a graph.

**INQUIRY FOCUS** Graph

**Procedure**

1. With your group, choose a question to ask your classmates. Your question should have between 4 and 6 possible answers, such as “What is your favorite subject in school?” or “What season were you born in?”

2. Survey your classmates to collect data. Make a data table on the back of this paper and record the data.

3. As a group, decide how you will show the data in a graph. Think about what information needs to be included so that someone looking at your graph will be able to understand it and draw conclusions.

4. Use the poster paper and markers to create your graph.

5. Compare your graph with other groups’ graphs.

**Think It Over**

1. Describe any patterns or trends you see in your graph.

2. What kinds of labels did you and your classmates use in your graphs? How do the labels help you understand the graphs?

3. How do you think graphs can help scientists analyze data?
Recognizing Trends

Scientists use graphs to identify trends in data and make predictions. In this activity, you will make a graph to show a trend in data from a table. Then, you will make a prediction based on the graph.

**INQUIRY FOCUS** Graph, Predict

**Procedure**

1. Fill the beaker with cold tap water. Use the thermometer to measure the temperature of the water. Record the temperature in the data table.

2. Add one sugar cube to the beaker. Use the plastic spoon to stir the water steadily (use the same stirring action with each trial). Use a stopwatch to time how long it takes the sugar cube to dissolve completely in the water. Record this time in the data table.

3. Repeat Steps 1 and 2, first with lukewarm water and then with hot water.

4. On the graph paper, make a line graph by plotting the data from the table.

**Materials**

- beaker
- cold, lukewarm, and hot water
- thermometer
- small sugar cubes
- plastic spoon
- graph paper
- stopwatch
- goggles

**Think It Over**

1. Describe the trend in your graph.

2. How long do you predict it would take a sugar cube to dissolve in water at 80° C? Explain your prediction.
Models in Science

Models can be used to help illustrate many scientific concepts, but models do have some limitations. In this activity, you will model your classroom.

INQUIRY FOCUS Make Models

Procedure

1. With your group, brainstorm ways you could use the materials to make a model of your classroom. Decide if you want your model to be flat or three-dimensional, and how you will show different parts of the room. Finally, decide on a scale for your model.

<table>
<thead>
<tr>
<th>Actual Classroom (m)</th>
<th>Model Classroom (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td></td>
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<td>Width</td>
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<td>Depth of desktop</td>
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<tr>
<td>Etc…</td>
<td></td>
</tr>
</tbody>
</table>

2. Assemble your model.

3. Compare your model with other groups’ models.

Think It Over

1. If someone saw your model without seeing your classroom, what information would they learn about your classroom? What information would they not be able to learn?

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

2. How could you change your model so someone could learn more from it?

   ____________________________________________________________

   ____________________________________________________________

Materials

- scissors
- construction paper
- glue
- meter stick
Working With Models

Scientists build models to investigate things they cannot easily observe directly. In this activity, you will build models showing atoms that combine in chemical reactions to make new compounds.

INQUIRY FOCUS Make Models

Procedure

1. One atom of carbon can combine with one atom of oxygen in a chemical reaction to form carbon monoxide. Use the materials to make a model of this chemical reaction.

2. Two atoms of hydrogen and one atom of oxygen can combine to form dihydrogen oxide—what we commonly call water. Use the materials to make a model of this chemical reaction.

3. One atom of calcium, one atom of carbon, and three atoms of oxygen can combine to form calcium carbonate. Use the materials to make a model of this chemical reaction.

Think It Over

1. Which reaction was easiest to model? Which was most difficult? Explain why.

2. Give one advantage and one disadvantage of using models in scientific investigations.

Materials

- toothpicks
- chenille stems
- modeling clay
- foam balls
Characteristics of Systems

A system is a group of parts that work together to carry out a function. All systems have at least one input, at least one process, and at least one output. In this activity, you will make a model of a real-world system. Then, you will analyze how your model relates to the actual system.

INQUIRY FOCUS Make Models, Analyze Models and Systems

Procedure

1. A doorbell is part of a system. Discuss with your group how a doorbell works and what parts make up a doorbell system. Then, discuss how you could use the materials to make a model of a doorbell system. Draw a sketch of your model system on the back of this sheet.

2. Make a model doorbell system with the materials.

3. After you have completed your model, check to see that it works. If it does not work, adjust the model until it does.

Think It Over

1. What are the input, output, and process in your model?

2. How is your model the same as an actual doorbell system? How is it different?

Materials

- 9-volt battery
- 3 wire leads with alligator clips
- buzzer
- switch
Selecting Models

Reviewing Content

Have you ever tried to understand the way something works when you can’t really see it? Scientists often use models to gain a better understanding of things that are difficult to study directly, such as stars and atoms. They also use models to represent processes, such as the movement of water through the Everglades, that are part of a system. Sometimes the systems scientists study are simple. A model of a simple system might have only a few parts or steps. Other times systems are very complex. In such cases, scientists might use a model for only the part of the system they want to study. For example, a hurricane is a complex natural system. Scientists might make a model to study only some of a hurricane’s winds.

In this lab, you will use a model to carry out a controlled experiment to investigate a question about the force of gravity.

Reviewing Inquiry Focus

Gravity is a force of attraction between two objects. This natural attraction between objects is a process that is difficult to investigate in a laboratory. Magnetism is also a force of attraction between some objects. Because the two forces are similar, scientists might use magnetic force as a model for the force of gravity in a laboratory investigation.

In this activity, you will use magnetism as a model for gravity. You’ll begin by writing a hypothesis about how distance affects magnetic force. Then, you will carry out a controlled experiment in which you make observations and collect data. From your data, you will draw a conclusion about magnetism. Then, you will infer what your model shows about gravity.

With these statements in mind, preview the Lab Investigation. Then answer the questions in the spaces provided.

1. In this investigation, what is being used as a model to explore the force of gravity?

2. What variable may affect the strength of both magnetic force and gravity?
Selecting Models

Problem

How can you use a model to show the relationship between distance and the strength of the force of gravity?

Procedure

1. Develop a hypothesis about the relationship between distance and the strength of magnetic force. Your hypothesis should state a possible answer to this question: How does the distance between a magnet and paper clips affect the strength of the magnetic force?

   Hypothesis:

2. Now test your hypothesis by observing how many paper clips a magnet attracts at increasing distances from the paper clips. Begin by using masking tape to attach the straw to one side of the bar magnet. Use the metric ruler to make sure that the straw extends 0.5 cm from the end of the magnet. This will be the distance from the magnet to the paper clips.

3. Place the paper clips in a loose pile on a sheet of paper. Lower the end of the magnet with the straw attached onto the pile of paper clips. The straw will keep the magnet above the pile of paper clips without the magnet actually touching the paper clips.

4. Count the number of paper clips the magnet picks up. Record the number in the Data Table on the next page.

5. Repeat Steps 2, 3, and 4 by extending the straw out from the magnet to these lengths: 1 cm, 1.5 cm, 2 cm, 2.5 cm, 3 cm. At each distance, count the number of paper clips the magnet picks up and record the number in the Data Table.

Materials

- strong bar magnet
- plastic straw
- metric ruler
- masking tape
- small paper clips
- pencil
## Data Table

<table>
<thead>
<tr>
<th>Length of Straw</th>
<th>Number of paper clips</th>
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<tr>
<td>5 mm</td>
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<td>1 cm</td>
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<td>1.5 cm</td>
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<td>2 cm</td>
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<tr>
<td>2.5 cm</td>
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<tr>
<td>3 cm</td>
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</tbody>
</table>
Analyze and Conclude

1. **Control Variables** In your experiment, what was the independent variable and what was the dependent variable?

2. **Graph** Graph the results shown in your Data Table. Plot the number of paper clips on the y-axis and the distance between magnet and paper clips on the x-axis.

   ![Graph](image)

   What does the graph reveal about the relationship between distance and how many paper clips the magnet picks up?

3. **Develop Hypotheses** Did your experiment provide the data you needed to evaluate your hypothesis? Why or why not?

4. **Draw Conclusions** What can you conclude from your results about how distance affects magnetic force?
Selecting Models

1. **Infer** Using the results of this experiment, what can you infer about how distance affects the force of gravity?

2. **Make Models** Is magnetic force a good model for the force of gravity in a laboratory investigation? Why or why not?

3. **Summarize** Summarize what you learned about using magnetic force as a model for studying gravity. List any questions that you still have.

   What I learned

   What I still want to know

**Identify Faulty Reasoning** Suppose that you write a science blog, and today you want to focus on people’s misunderstandings about gravity. Write a blog entry explaining the relationship between the strength of the force of gravity and the distance between objects. To help make your explanation clear, use your test on the model in this investigation as an example.
Selecting Models

Problem
How can you use a model to show the relationship between distance and the strength of the force of gravity?

Design an Experiment

1. In this investigation, you and your partner can use any of the listed materials to test a hypothesis about gravity using magnetic force as a model.

2. Develop a hypothesis about the relationship between distance and magnetic force for your experiment.

   Hypothesis:

3. Design an experiment that tests your hypothesis. Write a procedure in the notebook on the next page. Underneath your procedure, make a data table to record your observations.

4. Have your teacher review and approve your hypothesis and your procedure before testing it. After getting approval, carry out your experiment and record your results. As you plan your experiment, you might want to consider the following questions.

   a. How can the experiment be designed to test only for how distance affects the strength of magnetic force?

   b. How can you measure the strength of the force of a bar magnet?

   c. How can you design a data table in which you can record observations about distance and strength of magnetic force?
SELECTING MODELS continued

**Procedure**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Data Table

________________________________________________________________________
Analyze and Conclude

1. **Design Experiments** What were the independent and dependent variables in your experiment?

2. **Measure** In your experiment, how did you make sure your measurements of distance were accurate?

3. **Graph** Graph the results shown in your data table. Plot the number of test objects on the y-axis and the distance between the magnet and test objects on the x-axis. What does the graph reveal about the relationship between mass or distance and how many test objects the magnet attracts?

4. **Draw Conclusions** What can you conclude from your results about the factors that affect magnetic force?
Selecting Models

1  Infer Using the results of this experiment, what can you infer about factors that affect the force of gravity?

2  Make Models Why might a scientist decide to use magnetic force as a model for the force of gravity in a laboratory experiment? What is a drawback of using magnetic force to model gravity?

3  Summarize Summarize what you learned about using magnetic force as a model for studying gravity. List any questions that you still have.

   What I learned

   What I still want to know

Communicate

Relate Evidence and Explanation Design a presentation, such as a slide show, a poster, a video, or a computer presentation, to explain the results of this investigation to a class of fifth graders. Your presentation should be creative and interesting, but must also be scientifically accurate. In your presentation, be sure to include

• how scientists select a model to represent a process
• how you carried out the experiment
• what the results of the experiment mean about magnetic force
• what the results of this experiment may say about the force of gravity
Can You Name the Safety Equipment

Whether scientists are working with hazardous chemicals, fire, live animals, or many other possible dangers, they always take precautions. In this activity, you will become familiar with some science safety equipment.

**INQUIRY FOCUS** Infer

**Procedure**

1. Your teacher will describe how a piece of safety equipment might protect you. As a group, determine which object your teacher is describing.

2. Once your group makes a decision, hold up the piece of safety equipment or a picture of the equipment.

3. After all groups have held up their answer, your teacher will tell you the correct answer. Record the correct answer for each item.

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<th>Description</th>
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**Think It Over**

1. Why is it important to follow directions during lab work?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Materials

- lab apron or lab coat
- safety goggles
- fire extinguisher
- heat-resistant gloves
- plastic gloves
- hand soap
- first aid kit
- fire blanket
- hazardous waste container
Prepared to Be Safe in the Field

Being prepared to be safe in the field requires thinking ahead. In this activity, you will predict safety concerns that might arise in a field investigation. Then, you will decide what equipment you would need to be prepared for them.

INQUIRY FOCUS Design Experiments

Procedure

1. The terrarium represents a natural habitat where you will do a field investigation, and the safety equipment represents safety issues that might arise. Observe the terrarium and safety equipment. Then, with your partner, discuss safety concerns in the field that are different than safety concerns in the lab.

2. List three of your safety concerns. List which items of safety equipment you would use to address each concern.

Materials

- terrarium
- safety equipment

Think It Over

1. If you were studying an animal in the field like the animal in the terrarium, how would you handle it safely and humanely? Include any safety gear you would use.

2. Why should you always work with a partner and an adult in the field?
How Would You Respond to These Emergencies?

It’s important to know what to do if an accident occurs during a lab investigation. In this activity, you will learn the location of certain safety equipment in the lab.

**INQUIRY FOCUS Design Experiments**

**Procedure**

1. What should you always do first in any lab emergency?
   
   ____________________________
   
   ____________________________

2. Locate the emergency equipment in the classroom that would be used if each emergency below occurred. Record the number of the equipment. **CAUTION:** Do not use or operate any of the equipment or remove it from its place in the classroom. You should never use any safety equipment unless instructed to do so by your teacher.

   An electrical fire occurs. ________________
   
   Someone gets cut on a piece of broken glass. ________________
   
   A chemical is splashed in someone’s eyes. ________________
   
   Someone’s clothes catch on fire. ________________

**Think It Over**

1. Why is it important to know the location of emergency equipment?
   
   ____________________________
   
   ____________________________
   
   ____________________________

2. What are some ways you can avoid emergencies in the lab?
   
   ____________________________
   
   ____________________________
   
   ____________________________

SAFETY IN THE SCIENCE LABORATORY

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