Comparing the measurable properties of things in their daily life provides an automatic interest for children. Their natural curiosity leads them to explore the world by observing and manipulating the materials of their environment. By providing the instructional focus and introduction of age-appropriate tools and methods, teachers can lead students to develop the necessary precursors to the later introduction of more abstract properties in later grade levels.

During these learning experiences, students are introduced to the measurement of length with rulers and meter sticks, mass with double pan balances and gram stackers, volume with graduated containers, and temperature with thermometers. The units of centimeters, grams, milliliters, and degrees Celsius are introduced and reinforced through various problem-solving activities using hands-on materials. Students are also involved in designing “fair tests” and using patterns to make sense of their observations.
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Interdisciplinary Connections

See pages 45-50 for a complete wording of the Texas Essential Knowledge & Skills for each content area addressed in this learning experience.

Properties, Patterns, and Systems

- **Mathematics TEKS**
  - Quantitative reasoning
  - Collecting/organizing data
  - Measurement
  - Patterns and relationships
  - Geometry and spatial reasoning
  - Problem-solving

- **Language Arts TEKS**
  - Listening & speaking
  - Vocabulary development
  - Writing
  - Connecting reading, writing, and inquiry

- **Social Studies TEKS**
  - Problem-solving
  - Decision-making
  - Written, oral, and visual communication

- **Art TEKS**
  - Organizes information from environment
  - Creation of artworks
## Overview of Learning Experiences

| TEKS | 2.4 The student uses age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured. The student is expected to: (A) collect information using tools including rulers, meter sticks, measuring cups, clocks, hand lenses, computers, thermometers, and balances; (B) measure and compare organisms and objects and parts of organisms and objects, using standard and non-standard units.  
2.7 The student knows that many types of change occur. The student is expected to: (A) observe, measure, record, analyze, predict, and illustrate changes in size, mass, temperature, color, position, quantity, sound, and movement; (B) identify, predict, and test uses of heat to cause change such as melting and evaporation; (C) demonstrate a change in motion of an object by giving an object a push or a pull. |
| ENGAGE | ✦ Students participate in two contests to discover that the use of standardized units is important when conducting fair measurements. Reading and discussion of *Super Sand Castle Saturday* by Stuart Murphy reinforces the concept. |
| EXPLORE | ✦ Students use centimeter cubes to explore the lengths of different parts of their own hand. Conducting a simple investigation, students explore the concept of mass and operationally define the concept of volume. Exploring the property of temperature involves students using units of degrees Celsius with thermometers. |
| EXPLAIN | ✦ Students are introduced to the metric ruler and the use of centimeters as a unit. The double pan balance is used with gram stackers to measure mass and various cups and graduated containers are used to measure volume in milliliters. Students recognize the relationship between heat energy and changes and changes in matter. |
| ELABORATE | ✦ Students work in small groups to complete problem-solving activities that require the use of tools, measurement, and critical thinking. |
| EVALUATE | ✦ Formative assessments are embedded throughout the learning experiences and guide instruction and student learning.  
✦ Students work individually to complete a summative assessment with selected response items. |
ENGAGE

1. Present students with the following information:
   Today we are going to have a contest that is called
   the "Longest Necklace." Please listen carefully to
   the rules.

   - You will work together as a team to make a necklace
     by stringing pieces of macaroni onto a piece of yarn.
   - The container of macaroni must stay on this table.
   - The pieces of macaroni must be taken from the
     container one at a time.
   - The piece of yarn must stay on that table. (Point to a
     different table.)
   - Your necklace must show some type of repeated
     pattern.
   - All members of the team must have a job in making
     the necklace.
   - You will have 1 minute to make your necklace.
   - When you hear "stop," you must put everything down.
   - The team that makes the longest necklace will win.
     Remember, your necklace must have a repeated
     pattern and everyone in your team must have a job in
     making the necklace.

2. Review the rules and ask questions to check for
   students’ understanding.

3. Allow students time to meet with their team,
   discuss their plan, and assign jobs.

4. Review the rules if needed and start the race. After
   one minute, "stop" the students.

5. Have students sit down with their team and count the
   pieces of macaroni on their yarn.
6. Have each team share with the class their necklace and the pattern they made. For example: red, blue, green, red, blue, green, etc. Record the number of macaroni pieces for each team on a class chart.

7. Point to the team with the largest number recorded on the chart and ask the following types of questions:

- Did this team win our contest? How can you tell? (biggest number of macaroni pieces)
- Does everyone agree that this team made the longest necklace? (someone may point out that their group’s pieces of macaroni were smaller and that’s not fair; if no one brings it up, probe further.)
- Can we really tell which team has the longest necklace just by counting the pieces of macaroni? (no) Why not? (not all pieces are the same size; some pieces are longer)
- How can we find out which team really won the “Longest Necklace” contest? (hold them up to each other and compare their lengths)
- Compare the necklaces and congratulate the winning team.

8. Ask students if they are ready to do another contest called “Moving the Cup” contest. Discuss the following rules:

- A cup will be placed on your table along a starting line made of tape.
- You will move the cup as far as possible using only a plastic bottle. You may not touch the cup or use the bottle to touch the cup.
- You will have 15 seconds to move your cup as far as possible
- When you hear “stop”, put everything down.
- The team that moves the cup the longest distance will win.

<table>
<thead>
<tr>
<th>Longest Necklace Contest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1:</td>
<td>13 pieces</td>
</tr>
<tr>
<td>Team 2:</td>
<td>19 pieces</td>
</tr>
<tr>
<td>Team 3:</td>
<td>17 pieces</td>
</tr>
<tr>
<td>Team 4:</td>
<td>21 pieces</td>
</tr>
</tbody>
</table>
9. Your team will have a few minutes to practice moving the cup using a plastic bottle. As students are deciding how to move the cup without touching it, circulate through the room holding small group discussions about forces (pushes and pulls) and how they can cause an object to move. Students should problem solve to discover that they can squeeze the bottle to cause a puff of air to push the cup forward.

10. Have each team select one person to be in charge of causing the force that moves the cup during the contest. Other team members are in charge of showing support and encouragement.

11. Review the rules and ask questions to check for students’ understanding. Have each group place their cup on the starting line. Start the contest and after 15 seconds “stop” the contest.

12. Using craft sticks as units, have each team measure the distance their cup moved from the starting line. Record the distances on a class chart.

13. Point to the team with the largest number recorded on the chart and ask the following types of questions:

- Did this team win our contest? How can you tell? (biggest number of craft sticks)
- Does everyone agree that this team moved their cup the longest distance? (Someone may point out that their group’s craft sticks were smaller and that’s not fair; if no one brings it up, probe further.)
- Can we really tell which team moved the cup the longest distance just by counting the craft sticks? (no) Why not? (not all craft sticks are the same size; some are longer)

---

**Moving the Cup Contest**

<table>
<thead>
<tr>
<th>Team</th>
<th>Craft Sticks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>5</td>
</tr>
<tr>
<td>Team 2</td>
<td>6</td>
</tr>
<tr>
<td>Team 3</td>
<td>13</td>
</tr>
<tr>
<td>Team 4</td>
<td>7</td>
</tr>
</tbody>
</table>
How is this like the "Longest Necklace" contest? How did we find out which team really had the longest necklace? (held them up to each other and compared)

How is this different from the "Longest Necklace" contest? (cannot hold the lengths up to each other and compare)

Then how are we going to find out which team moved the cup the longest distance? (acknowledge all suggestions; lead class to select a method that uses a mutually agreed upon unit of measure to make a meaningful comparison and then use it to determine the winner)

Congratulate the winning team.

Ask students if they would like to read a book about a group of children who were also trying to win a contest.

14. Gather students in a reading circle to share Super Sand Castle Saturday by Stuart Murphy. Read the story aloud sharing the illustrations. During the post-reading discussion, ask the following types of questions:

What was the contest in the story about? (building the tallest tower, the deepest moat, and the longest wall on a sand castle)

How was the sand castle contest in the story like the contests we did today? (acknowledge all responses: not fair if you use different units)

How was the sand castle contest different from the contests we did today? (acknowledge all responses)

As you heard in the story, it can be very important to measure things fairly. What is something important that you have learned today about measuring? (acknowledge all responses: lead students to discuss the importance of using the same units or it will not be a fair measurement)
• At the end of the story, who decided which tower was the tallest, which moat was the deepest, and which wall was the longest?  (*Larry the lifeguard*)
• What did he use to make the measurements?  (*some students may say meter stick, ruler, or measuring tape*)
• Bring out some measuring tools such as a measuring tape and a ruler.  Ask students if these tools could have been used to help us make fair measurements in "The Longest Necklace" contest and the "Moving the Cup" contest.  (*yes*)
• At the end of the story, Larry the lifeguard said, "Spoons and shovels and people’s feet can all be different sizes, but an inch is always an inch."  What did Larry mean when he said this?  (*acknowledge all responses*)
• Inform students that in the next few days, they will investigate the use of tools to help make sure that all are measurements are fair.
EXPLORE
Length

1. Have students trace one of their hands onto a page in their journal. In some cases, students may need to help each other. Have groups develop a plan for measuring the lengths of each of their fingers so that we can compare them in a fair way. Facilitate the discussions emphasizing the use of standard units, defining a starting line, and placing units end-to-end. Record agreed upon rules on a class chart.

2. Have each student use a red crayon to mark the starting line for each finger. Have students discuss and/or write a prediction. For example, “I predict my thumb is longer than my little finger”, etc.

SAFETY FIRST ALERT
Remind students to avoid putting objects into their mouths.

3. Place a container of centimeter cubes at each group and allow students to measure and record the length of each finger and thumb in units of cubes. Circulate through each group making sure students understand the rules for making a fair measurement and are recording data with both a number and a unit.

4. Have students compare their findings and be ready to share their most interesting information with the class.
1. Have students communicate their findings by participating in a class discussion. Record data on a class chart using the symbols “<, =, >” to describe relationships between data. For example, the length of Bill’s thumb is > the length of Jean’s thumb.

2. Place a metric ruler in front of each student. Have students take one of the centimeter cubes and place it on the ruler at the starting line. Ask students where is the starting line? (zero) How long is the cube? (one) Record data on class chart. How long are two cubes? (two) How long are three cubes? (three) Do you see a pattern? (yes, both sides of the chart are going up the same) Predict what the number on the ruler will be if we use 10 cubes. (10) Try it and find out if you are right. Let’s add that to our chart.

3. Introduce the word “centimeter” to students. Have them say it and write it. Explain that each number on their ruler equals one centimeter and that it is often abbreviated as cm. Discuss why we use abbreviations and ask what are some other examples of abbreviations they know. Go back to the class chart and add cm as a unit for each number under the ruler column.

4. Find some body part that you always have with you that is very close to the same size as 1 cm. Give students a few minutes to use their ruler to decide upon the part. Most students will recognize that one of their fingers is about 1 cm wide. For the average adult, the width of the little finger or the fingernail on the little finger is about 1 cm. For second graders, a different finger may be more appropriate. Have pairs of students share their 1 cm parts and verify the measurement using a ruler.

### MATERIALS (details p. 39)

**For the class:**
- chart paper
- markers
- container of centimeter cubes
- copies of Masters A-B

**For each group:**
- metric ruler
- set of 5 Cuisenaire® rods

**For each student:**
- crayons
- set of 5 Cuisenaire® rods
- copies of Masters A-B

<table>
<thead>
<tr>
<th># of Cubes</th>
<th># on Ruler</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cube</td>
<td>1 cm</td>
</tr>
<tr>
<td>2 cubes</td>
<td>2 cm</td>
</tr>
<tr>
<td>3 cubes</td>
<td>3 cm</td>
</tr>
<tr>
<td>10 cubes</td>
<td>10 cm</td>
</tr>
</tbody>
</table>
Facilitate the sharing and assist in settling disagreements if needed.

5. Have students put the rulers away and give each student a copy of *Master A* and a set of 5 Cuisenaire® Rods with 1 each of these colors: red, purple, dark green, brown, and orange. Using their own "cm part", have students record their prediction of each rod’s length. Ask students if they see any patterns in their numbers. *(acknowledge all answers)*

6. Using a ruler, have each student measure and record the length of each rod. Once again, ask students if they see any patterns in their numbers. *(numbers are counting by twos)*

7. Have students sequence their 5 rods from shortest to longest remembering to use a starting line such as the edge of their paper. Ask the students to think again about the pattern in their numbers. Have students move the red rod to the top of the purple rod. What do they notice? *(red + purple = dark green)* Now move the red rod to the top of the dark green rod. What do they notice? *(red + dark green = brown)* Now move the red rod to the top of the brown rod. What do they notice? *(red + brown = orange)* What pattern do you see? *(2 cm is added each time thus, we are counting by twos)*

8. Refer students to “Adding lengths” on *Master A* and complete the first row together. Have students place red and purple rods end-to-end and find the color of rod that has that length. They will find that the lengths of red + purple = dark green length. Have students write dark green in the right hand column. Allow students to complete the table facilitating as needed. Emphasize the importance of always using a starting line.
9. Refer students to "Comparing lengths" on Master B and complete the first row together. Have students place dark green and purple rods end-to-end. Have students place red and orange end-to-end and compare the lengths of the two combinations rods. Have students write in the symbols for less than, equal to, or greater than in the middle column. Allow students to complete the table facilitating as needed. Emphasize the importance of always using a starting line.

10. Refer students to "Adding centimeters" on Master B and complete the first row together. Have students use a metric ruler to measure and record the length of the red rod (2 cm). Have students measure and record the length of the purple rod (4 cm). Ask students to add 2 cm + 4 cm and record their answer of 6 cm. Have students measure the length of the dark green rod to check their answer of 6 cm.

11. Have students practice using a metric ruler to draw straight lines of different lengths in their journals. Have students label each line with the appropriate length in centimeters, exchange with a partner, and discuss if they agree with each other’s measurements.
# Measuring Length

(See Master A)

<table>
<thead>
<tr>
<th>Color</th>
<th>My prediction</th>
<th>My measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>purple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dark green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>orange</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Adding lengths:

\[
\text{red + purple} = \\
\text{dark green + purple} = \\
\text{brown + red} = \\
\text{dark green + red} = \\
\text{orange + red} = \\
\text{orange + purple} = 
\]
Comparing lengths:  

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>dark green + purple</td>
<td>red + orange</td>
<td></td>
</tr>
<tr>
<td>orange + purple</td>
<td>dark green + brown</td>
<td></td>
</tr>
<tr>
<td>orange + dark green</td>
<td>brown + purple</td>
<td></td>
</tr>
<tr>
<td>red + orange</td>
<td>purple + brown</td>
<td></td>
</tr>
<tr>
<td>dark green + purple</td>
<td>brown + red</td>
<td></td>
</tr>
</tbody>
</table>

Adding centimeters:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td>purple</td>
<td>dark green</td>
</tr>
<tr>
<td>______________ cm</td>
<td>______________ cm</td>
<td>______________ cm</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>purple</td>
<td>dark green</td>
<td>orange</td>
</tr>
<tr>
<td>______________ cm</td>
<td>______________ cm</td>
<td>______________ cm</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>dark green</td>
<td>red</td>
<td>brown</td>
</tr>
<tr>
<td>______________ cm</td>
<td>______________ cm</td>
<td>______________ cm</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>brown</td>
<td>red</td>
<td>orange</td>
</tr>
<tr>
<td>______________ cm</td>
<td>______________ cm</td>
<td>______________ cm</td>
</tr>
</tbody>
</table>
1. Ask students to describe what makes things move. For example, what could we do to this table to make it move? (push or pull it) Would it be easier to move this table or this pencil? (most will say pencil) Why? (most will say table is too heavy) Would the table or the pencil take more “push” to make it move? (table) Ask students to keep thinking about “push” as they do the next investigation.

2. Provide each group with the listed materials. Explain that their job is to conduct a fair test to find out how far a moving golf ball can push each of the two pudding boxes. The amount of teacher assistance in developing the investigative plan will vary depending upon students’ experiences. If needed, conduct a class discussion to set up the plan together and draw diagrams on chart paper for students to use. The basic design should include using a ruler to make a ramp for the ball to roll down and push into the box. A meter stick can be placed in line with the box so that the distance traveled in cm can be recorded. To maintain a fair test, students should keep the same setup changing only the pudding box as their variable.

3. Have students complete the tests and record how far the boxes moved when the ball pushed them.
EXPLAIN

Mass

1. Have students communicate their findings by participating in a class discussion. Record data on a class chart. Ask students if they see any patterns in the data. (heavy box moved the fewest cm; light box moved the most cm)

2. Introduce students to the term “mass” by writing it, having them say it out loud, and writing it in their journals. Explain that the heavy box has more mass and that is why it is harder for the ball to push it. Explain that the lighter box has less mass and that is why it is easier for the ball to push it. Refer students back to the question about moving the table and the pencil. Why is it harder to push the table than the pencil? (table has more mass; pencil has less mass)

3. Bring out the double pan balances. Explain that these are tools to measure mass. Ask students to predict what will happen when you place the full pudding box on one pan and the empty pudding box on the other pan. (side with full box will go down) Have students try it and verify their thinking.

4. Using a double pan balance and centimeter/gram cubes, walk students through the process of measuring the mass of an object using the cubes. Have students place the cubes in a straight line on the grid of Master C. Discuss that the starting line is located at the bottom. Have students draw the object in the box and then color in the same number of squares as cubes. Walk students through the process of measuring the mass of a second object using the cubes. Have students place the cubes onto the grid remembering that the starting line is at the bottom. Have students draw the object in the box and then color in the same number of squares as cubes. Have students
return all cubes to the container.

5. Have students study their graph and predict what will happen when both objects are placed on the balance in separate pans. *(object with most cubes/squares on the graph will cause the pan to go down; object with least cubes/squares on the graph will go up)* Have students test their predictions and explain what happened. *(object with most cubes/squares on graph has most mass)* Ask which object needs more "push" to make it move. *(object with most mass)*

6. Provide each group with a set of gram stackers. Have students use the centimeter/gram cubes to measure the mass of one red stacker; record results on class chart. Repeat for one blue, one green, and one yellow stacker. Ask students to compare data for # of cubes with the information stamped on top of each color of stacker. Students should identify the pattern that # of cubes equals number stamped on stacker. Ask students if they might know what the "g" on each sticker means. Some may recognize the "g" refers to the "grams" written on class chart. Revisit the previous discussion about the use of abbreviations. Emphasize that g stands for grams and is a unit for measuring mass just as cm stands for centimeter and is a unit for measuring length. Record the number of grams in final column on class chart.

<table>
<thead>
<tr>
<th>Color</th>
<th># of cubes</th>
<th># of grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>blue</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>green</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>yellow</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

7. Give each group 10 small objects and a sorting mat such as Master D. Working as a group, have students place the 10 objects into one of the 3 boxes on the mat.

8. Have students write "Predicting Mass" in their journal. On a class chart, demonstrate how to draw and label the three boxes: < 1 g, = 1 g, and > 1 g. Have students draw pictures in the boxes to record their estimates.
9. Have each group measure the objects and place on a sorting mat such as Master E. Have students write “Measuring Mass” in their journal. On a class chart, demonstrate how to draw and label the three boxes: < 1 g, = 1 g, and > 1 g. Have students draw pictures in the boxes to record their measurements. Discuss results.

10. Refer students to “Comparing Masses” on Master F. Complete the first row together by having students place 10 toothpicks on one pan of the balance and a 10 g stacker on the other pan. Discuss with students if they should record <, =, or > in the box. Allow students time to work together to complete the other seven comparisons.

11. Refer students to “Measuring Masses” at the bottom of Master F. Allow students time to work together to make their predictions and record their actual measurements.
Measuring Mass (See Master C)

<table>
<thead>
<tr>
<th>Mass (# of cubes)</th>
<th>20</th>
<th>19</th>
<th>18</th>
<th>17</th>
<th>16</th>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
</table>

Mass (# of cubes)
Predicting Mass

> 1 gram

= 1 gram

< 1 gram

See Master D
Measuring Mass

See Master E

> 1 gram

= 1 gram

< 1 gram
Comparing Masses (See Master F)

<table>
<thead>
<tr>
<th>Object</th>
<th>My prediction</th>
<th>My measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 toothpicks</td>
<td>10 grams</td>
<td>10 grams</td>
</tr>
<tr>
<td>6 bottle caps</td>
<td>21 grams</td>
<td>21 grams</td>
</tr>
<tr>
<td>5 marshmallows</td>
<td>6 grams</td>
<td>6 grams</td>
</tr>
<tr>
<td>4 clothespins</td>
<td>15 grams</td>
<td>15 grams</td>
</tr>
<tr>
<td>5 cotton balls</td>
<td>5 grams</td>
<td>5 grams</td>
</tr>
<tr>
<td>5 bottle caps</td>
<td>8 grams</td>
<td>8 grams</td>
</tr>
<tr>
<td>5 toothpicks</td>
<td>1 gram</td>
<td>1 gram</td>
</tr>
<tr>
<td>2 paper clips</td>
<td>1 gram</td>
<td>1 gram</td>
</tr>
</tbody>
</table>

Measuring masses:

<table>
<thead>
<tr>
<th>Object</th>
<th>My prediction</th>
<th>My measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>crayon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>scissors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ruler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>marker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>glue stick</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
EXPLORE

Volume

1. Give each group a level cup of rice. Ask them for words that would describe how much rice is in the cup. (full) Have them carefully pour the rice into the left pan of their balance. Ask students to add gram stackers to the right pan until the pans are balanced. Have students determine the mass of the rice by adding together the number of grams from all stackers in the right pan. Record the mass of the rice in grams. **Do not remove the gram stackers from the balance.**

2. Using cups of the same size, give each group an empty cup marked “A”, a cup holding a rock marked “B”, and a cup holding a larger rock marked “C”. Have students draw and label the 3 cups in their journals. Ask students to predict what will happen if they pour the rice from the pan into “Cup A”. (acknowledge all responses)

3. Have students pour the rice from the pan into “Cup A” being very careful not to lose any rice. Placing the cup on a small tray helps retrieve any rice that is spilled. Students should recognize that “Cup A” is full. Have students record their observations by adding to their drawing of “Cup A”. Ask students to predict what will happen if they pour the rice from “Cup A” onto the left pan. (pans will be balanced again) Have students test their predictions. Discuss that moving the rice from one place to another, or changing containers, does not change the mass of the rice.

4. Have students place “Cup B” on the tray and carefully pour the rice from the pan into the cup. Students will find that the rice overflows and will not fit into the space of “Cup B”. Have students record their

**MATERIALS** (details p. 40)

- For the class:
  - chart paper
  - markers

- For each group:
  - double pan balance
  - gram stackers
  - 1 small tray
  - 1 plastic cup of rice
  - 1 empty plastic cup
  - 2 plastic cups with rocks
observations by adding the overflowing rice to their drawing of “Cup B”.

5. Have students place “Cup C” on the tray and carefully pour all the rice from the tray and “Cup B” into the cup. Students will find that the rice overflows even more and will not fit into the space of “Cup C”. Have students record their observations by adding the overflowing rice to their drawing of “Cup C”. 
1. Discuss with students their findings. Ask why the rice fit into “Cup A” but not into “Cup B”. Lead students to realize that the amount of space inside “Cup A” was equal to the space that the rice takes up. However, the rock in “Cup B” was taking up space so there was not enough space left to hold all of the rice.

2. Introduce students to the term “volume” by writing it on a class chart, having them say it out loud, and writing it in their journals. Discuss with students that the amount of space that the rice takes up is its “volume.” Ask why the rice did not fit into “Cup C”. Lead students to realize that the rock in “Cup C” also has volume and was taking up space in the cup. Therefore, there was not enough space left in the cup to hold the complete volume of the rice.

3. Give each group a 1 mL measuring spoon, two small containers, and a cup of water. Refer students to Master G and have them draw the two containers in the boxes at the bottom of the sheet. Have students use the spoon to fill the containers with water and color in one square for each spoonful used.

4. Ask students to predict what it will look like if they pour the water from each full container into 2 cups of equal size and shape. (acknowledge all responses) Have students pour the water from each container into the two cups. Have students compare their observations to their graphs and see that the container with the most squares on the graph fills the cup to a higher level.

Pour water into cups of equal size and compare levels of water to number of square on graph.
5. Have students look at the measuring spoon and read that it has “1 mL” stamped on it. Tell students that “mL” is the abbreviation for milliliters and is a unit for measuring volume. Ask students to share other abbreviations they have learned. (g for grams and cm for centimeters) Have students record this information in their journals. Ask students to look more closely at the two cups and notice that there are lines and numbers stamped on them. Explain that it is useful to have tools with these types of markings to measure volumes. Compare the mL readings of the water levels in the cups to the students' graphs and discuss as appropriate.

6. Have students complete Stations 1-4. Explain that their job is to work as a team to make careful observations and measurements as they visit each station and learn more about the volume of matter.

7. Allow ample time for students to manipulate materials and discuss observations.

- Remind students to avoid putting any of the objects from the stations into their mouth.
- All water spills must be reported to the teacher immediately for cleanup. Wet floors can be dangerously slippery.

8. Circulate through the working student groups while making formative assessments and redirecting student thinking as needed.
Station 1

Which one holds more?
Draw and label your prediction.

Pour 300 mL of water into each.
What did you find out?
Station 2

Which one holds more than 700 mL?
Draw and label your prediction.

Pour 700 mL of rice into each.
What did you find out?
Station 3

How many cups of rice will each bowl hold?
Draw and label your prediction.

Fill each bowl with cups of rice.
What did you find out?
Station 4

Which one will hold 600 mL?
Draw and label your prediction.

Pour 600 mL of water into each.
What did you find out?
EXPLORE Temperature

1. Ask each group to sequence the 3 cups from coolest to warmest based upon how the cups feel. Have students record their sequence with drawings in their journals.

2. Have each group place one thermometer into each cup and discuss any changes they observe. They should find that the red line of the thermometer in ice goes down; the red line of the thermometer in warm water goes up; and the red line of the thermometer in air does not change. Have students record these observations in their journals beside their drawings.

3. Ask students to predict what might happen to the red line of the thermometer if they add ice to the cup of warm water. (red line will go down) Have students use a plastic spoon to move some of the ice into the cup of warm water and observe the changes. Allow students time to explore and discuss their observations and questions.
EXPLAIN
Temperature

1. Discuss with students their findings. Ask why the red line on the thermometer changed. (acknowledge all responses) At this age, a simple, descriptive explanation will suffice.

2. Have students observe their thermometers and look for abbreviations. Write “°C” on a class chart and ask if anyone knows what it means. (degrees Celsius) Explain that °C is the abbreviation used for measuring temperature just as mL is used for measuring volume, g is for measuring mass, and cm is for measuring length. Have students record this information in their journals.

SAFETY FIRST ALERT

- Remind students to avoid putting any of the objects from the stations into their mouth.
- All water spills must be reported to the teacher immediately for cleanup. Wet floors can be dangerously slippery.
- Do not use water warmer than 55°C.

3. Have students place a thermometer into each of three cups: one with tap water, one with warm water, and one with very warm water. Have students draw the cups of water in their journals and label with the appropriate temperature in degrees Celsius.

4. Give each group 3 small cups containing two chocolate chips each. Demonstrate to students how a clothespin can be used to hold the small cup into the cup of water.

5. Have students hold the small cups in the water for 1 minute and then remove. Compare the chocolate chips in each cup and record observations in journal with drawings.

MATERIALS (details p. 42)
For the class:
- chart paper
- markers
- timing device

For each group:
- 3 thermometers
- cup of tap water
- cup of warm water
- cup of very warm water
- chocolate chips
- 3 small, clear cups
- 3 clothespins
6. Discuss with students the changes they observed in the chocolate chips. Lead students to realize that the changes are related to the temperatures of the water.
1. Have students work in small groups to complete the four problem-solving activities. Explain to students that they must record information in their journal to show how they got their answers. The use of both drawings and words should be encouraged.

**MATERIALS** (details pp. 42-43)

For each group:

**Activity 1**
- plastic sack
- balance
- 6 items to mass
- Activity card, *Master L*

**Activity 2**
- meter stick
- paper strips
- 3 plastic lids
- pre-made example
- Activity card, *Master M*

**Activity 3**
- 125 mL measuring cup
- 3 cups labeled A, B, C
- 3 labeled containers of water: tap, warm, cold
- food coloring
- tray
- Activity card, *Master N*

**Activity 4**
- plastic glass
- 3 bottles of water labeled juice A, B, C
- 3 large containers
- tray
- Activity card, *Master O*
EVALUATE

Have students work individually to complete the selected response item assessment.
Units Matter Assessment (See Masters Q-S)

How long is the bug?
○ 1 centimeter
○ 2 centimeters
○ 2 milliliters

What is the mass of the jar?
○ 15 grams
○ more than 15 grams
○ less than 15 grams
Study the graph. Which picture shows how the balance will look after you put the crayon and the key on the pans?
Study the graph. Which picture below shows how much water is in Cup B?

In which cup will the ice cube melt the fastest?
Materials Detail Sheet

**ENGAGE**

For the class:
- chart paper
- markers
- timing device
- *Super Sand Castle Saturday*, by Stuart J. Murphy, ISBN#0-06-446720-1

For each group of students:
- container of colored macaroni; use two sizes of macaroni with straight sides for example rigatoni comes in different lengths
  - color the macaroni pieces by placing in plastic bag with water and food coloring for 3 minutes, drain, spread out to air dry
  - give all groups except one the same size macaroni pieces; give one group a different size
- yarn or boot lace with cardboard square secured to one end
- run lace through hole in cardboard; tie knot on this side
- squeeze bottle; use empty bottles from shampoo or dishwashing liquids; however, it is important to give each team the same size and type of bottle; empty bottles for dispensing ketchup or mustard can be purchased at discount stores
- plastic cup
- masking tape
- craft sticks; use two sizes with one being considerably longer than the other
  - give all groups except one the same length of craft sticks; give one group a different length

**EXPLORE—Length**

For the class:
- chart paper
- markers

For each group of students:
- crayons
- container of centimeter cubes
**EXPLAIN**-Length
For the class:
- chart paper
- markers

For each group of students:
- crayons
- container of centimeter cubes

For each student:
- metric ruler
- set of 5 Cuisenaire® rods: red, purple, dark green, brown, and orange
- copies of Masters A-B

**EXPLORE**-Mass
For the class:
- chart paper
- markers

For each group of students:
- grooved ruler
- golf ball
- full box of pudding mix
- empty box of pudding mix; remove pudding mix and glue box shut
- meter stick
- books or blocks

**EXPLAIN**-Mass
For the class:
- chart paper
- markers

For each group of students:
- pudding boxes from Explore section
- double pan balance
2 objects with masses less than 20 grams
- centimeter/gram cubes
- gram stackers
- 10 small objects: miniature marshmallows, toothpicks, cotton balls, cotton swabs, straws, pencil erasers, clothespins, soda bottle caps, large paper clips, buttons
- 1 of each: crayon, marker, ruler, glue stick, scissors
- sorting mats, Masters D-E

For each student:
- copy of Master C
- copy of Master F

**EXPLORE** - Volume

For the class:
- chart paper
- markers

For each group of students:
- double pan balance
- gram stackers
- 1 small tray
- 1 plastic cup of rice
- 1 empty plastic cup labeled Cup A
- 2 plastic cups with rocks: glue a rock, one larger than the other, into the bottom of each cup; label Cup B and Cup C

**EXPLAIN** - Volume

For the class:
- chart paper
- markers

For each group:
- 1 mL measuring spoon
- 2 small containers such as bottle caps, jar lids, or anything with volume < 20 mL
## Units Matter

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>cup of water</td>
<td>cup of water</td>
<td>cup of water</td>
<td>cup of water</td>
</tr>
<tr>
<td>2 small graduated cups; plastic medicine cups work well</td>
<td>2 small graduated cups; plastic medicine cups work well</td>
<td>2 small graduated cups; plastic medicine cups work well</td>
<td>2 small graduated cups; plastic medicine cups work well</td>
</tr>
<tr>
<td>crayons</td>
<td>crayons</td>
<td>crayons</td>
<td>crayons</td>
</tr>
<tr>
<td>Station card, Master H</td>
<td>Station card, Master I</td>
<td>Station card, Master J</td>
<td>Station card, Master K</td>
</tr>
<tr>
<td>container or water</td>
<td>container or rice</td>
<td>container or water</td>
<td>container or water</td>
</tr>
<tr>
<td>graduated container</td>
<td>graduated container</td>
<td>graduated container</td>
<td>graduated container</td>
</tr>
<tr>
<td>tray</td>
<td>tray</td>
<td>tray</td>
<td>tray</td>
</tr>
<tr>
<td>half pint water bottle</td>
<td>half pint water bottle</td>
<td>half pint water bottle</td>
<td>half pint water bottle</td>
</tr>
<tr>
<td>shortening package</td>
<td>shortening package</td>
<td>shortening package</td>
<td>shortening package</td>
</tr>
<tr>
<td>plastic cup</td>
<td>plastic cup</td>
<td>plastic cup</td>
<td>plastic cup</td>
</tr>
<tr>
<td>Station 2</td>
<td>Station 3</td>
<td>Station 4</td>
<td>For each student:</td>
</tr>
<tr>
<td>container of rice</td>
<td>container of rice</td>
<td>container of water</td>
<td>copy of Master G</td>
</tr>
<tr>
<td>graduated container</td>
<td>graduated container</td>
<td>250 mL measuring cup</td>
<td></td>
</tr>
<tr>
<td>tray</td>
<td>tray</td>
<td>tray</td>
<td></td>
</tr>
<tr>
<td>oatmeal canister</td>
<td>oatmeal canister</td>
<td>2 bowls</td>
<td></td>
</tr>
<tr>
<td>chip canister</td>
<td>chip canister</td>
<td>large craft stick</td>
<td></td>
</tr>
<tr>
<td>large craft stick</td>
<td>large craft stick</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each student:
- copy of Master G
EXPLORE - Temperature

For the class:
- chart paper
- markers
- timing device

For each group of students:
- cup of warm water; approximately 40°C
- cup of ice
- cup of air
- 3 thermometers
- plastic spoon

EXPLAIN - Temperature

For the class:
- chart paper
- markers

For each group of students:
- 3 thermometers
- cup of tap water
- cup of warm water; 35-40°C
- cup of very warm water; do not exceed 55°C
- chocolate chips; milk chocolate melts more readily than semi-sweet chocolate
- 3 small, clear cups
- 3 clothespins

ELABORATE

For each group:
Activity 1
- plastic sack
- balance
- 6 items: bag of beans, bag of macaroni, box of tissue, box of crackers, bottle of water, bar of soap
- Activity card, Master L
### Activity 2
- meter stick
- paper strips; cut thin strips approximately 40 cm long
- 3 plastic lids; 1 circle-shaped, 1 square-shaped, and 1 triangle-shaped
- example: make an example by gluing a picture on inside of a lid and decorating outside edge with ribbon
- Activity card, Master M

### Activity 3
- 125 mL measuring cup
- 3 cups labeled A, B, C
- 3 labeled containers of water: tap, warm, cold
- food coloring
- tray
- Activity card, Master N

### Activity 4
- plastic glass
- 3 bottles of colored water labeled juice A, B, C
- 3 large containers
- tray
- Activity card, Master O

### EVALUATE
For each student:
- copy of Masters P-R
Background Information for Teachers

We are constantly involved in the measurement and the application of measurement in our daily lives. To explore the properties of matter, students must have many opportunities to develop the concepts of measurable properties such as length, mass, volume, and temperature. During this set of learning experiences, students are introduced to these measurable properties, the age-appropriate tools to use to make the measurements, and the metric units of centimeters, grams, milliliters, and degrees Celsius.

The most basic measurement is linear. These learning experiences involve the one-dimensional measurement of length. Centimeter cubes are first used for measuring the parts of the student’s hand. The cm cubes are then related to the cm units on a metric ruler and a meter stick. Students apply the measurement and the units in different situations. The process of always beginning the measurement at a set “starting line” is critical for student success.

Mass is not the same as weight. Mass is a constant for any given object and is a measure of its amount of matter. Weight, however, is dependent upon the pull of gravity on the object and can vary due to location. Mass is measured with a balance and the unit emphasized in these lessons is the gram.

Volume is known as the amount of space an object takes up. Liquid volume measurements in the metric system are generally made in liters and milliliters. These learning experiences introduce the unit of milliliters. Precise measurements are not expected, but this age level can determine appropriate gross measurements.

The difference between heat and temperature are not emphasized at this grade level. Instead, students are expected to relate the rise and fall in the fluid level of a thermometer to the hotness or coldness of a substance. This change in level occurs because as liquids heat up, they expand and take up more space inside the closed system of the thermometer. In contrast, as liquids cool, they contract and take up less space inside the thermometer. Students also explore simple changes in matter that can be caused by a rise in temperature.
Targeted Texas Essential Knowledge & Skills

Science TEKS

2.1 The student conducts classroom and field investigations following home and school safety procedures. The student is expected to:
   (A) demonstrate safe practices during classroom and field investigations.

2.2 The student develops abilities to do scientific inquiry in the field and the classroom. The student is expected to:
   (A) ask questions about organisms, objects, and events;
   (B) plan and conduct simple descriptive investigations;
   (C) compare results of investigations with what students and scientists know about the world;
   (D) gather information using simple equipment and tools to extend the senses;
   (E) construct reasonable explanations and draw conclusions using information and prior knowledge;
   (F) communicate explanations about investigations.

2.3 The student knows that information and critical thinking are used in making decisions. The student is expected to:
   (A) make decisions using information;
   (B) discuss and justify the merits of decisions; and
   (C) explain a problem in his/her own words and identify a task and solution related to the problem.

2.4 The student uses age-appropriate tools and models to verify that organisms and objects and parts of organisms and objects can be observed, described, and measured. The student is expected to:
   (A) collect information using tools including rulers, meter sticks, measuring cups, clocks, hand lenses, computers, thermometers, and balances; and
   (B) measure and compare organisms and objects and parts of organisms and objects using standard and non-standard units.
2.5 The student knows that organisms, objects, and events have properties and patterns. The student is expected to:
   (A) classify and sequence organisms, objects, and events based on properties and patterns; and
   (B) identify, predict, replicate and create patterns including those seen in charts, graphs, and numbers.

2.7 The student knows that many types of change occur. The student is expected to:
   (A) observe, measure, record, analyze, predict, and illustrate changes in size, mass, temperature, color, position, quantity, sound, and movement.
   (B) identify, predict, and test uses of heat to cause change such as melting and evaporation; and
   (C) demonstrate a change in the motion of an object by giving the object a push or a pull.

Language Arts TEKS

2.1 Listening/speaking/purposes. The student listens attentively and engages in a variety of oral language experiences. The student is expected to:
   (A) determine the purposes for listening such as to get information, to solve problems, and to enjoy and appreciate;
   (B) respond appropriately and courteously to directions and questions;
   (C) participate in rhymes, songs, conversations, and discussions;
   (D) listen critically to interpret and evaluate; and
   (E) listen responsively to stories and other texts read aloud, including selections from classic and contemporary works.

2.3 Listening/speaking/audiences/oral grammar. The student speaks appropriately to different audiences for different purposes and occasions. The student is expected to:
   (C) ask and answer relevant questions and make contributions in small or large group discussions.

2.4 Listening/speaking/communication. The student communicates clearly by putting thoughts and feelings into spoken words. The student is expected to:
   (A) use vocabulary to describe clearly ideas, feelings, and experiences;
   (B) clarify and support spoken messages using appropriate props such as objects, pictures, or charts;
2.8 Reading/vocabulary development. The student develops an extensive vocabulary. The student is expected to:
   (A) discuss meanings of words and develop vocabulary through meaningful/concrete experiences.

2.9 Reading/Comprehension. The student uses a variety of strategies to comprehend selections to be read aloud and selections read independently. The student is expected to:
   (A) use prior knowledge to anticipate meaning and make sense of texts;
   (B) establish purposes for reading and listening such as to be informed, to follow directions, and to be entertained;
   (I) represent text information in different ways, including story maps, graphs, and charts.

2.10 Reading/literary response. The student responds to various texts. The student is expected to:
   (A) respond to stories and poems in ways that reflect understanding and interpretation in discussion (speculating, questioning) in writing, and through movement, music, art, and drama;
   (B) demonstrate understanding of informational text in various ways such as through writing, illustrating, developing demonstrations, and using available technology; and
   (C) support interpretations or conclusions with examples drawn from text.

2.12 Reading inquiry/research. The student generates questions and conducts research using information from various sources. The student is expected to:
   (E) interpret and use graphic sources of information such as maps, charts, graphs, and diagrams;
   (H) draw conclusions from information gathered.

2.20 Writing/inquiry/research. The student uses writing as a tool for learning and research. The student is expected to:
   (B) record his/her own knowledge of a topic in various way such as by drawing pictures, making lists, and showing connections among ideas.
Mathematics TEKS

2.1 Number, operation, and quantitative reasoning. The student understands how place value is used to represent whole numbers. The student is expected to use concrete models to represent, compare, and order whole number (through 999), read the numbers, and record the comparisons using numbers and symbols (>,<,=).

2.3 Number, operation, and quantitative reasoning. The student adds and subtracts whole numbers to solve problems. The student is expected to:
   (A) recall and apply basic addition facts (sums to 18).

2.6 Patterns, relationships, and algebraic thinking. The student uses patterns to describe relationships and make predictions. The student is expected to:
   (C) identify, describe, and extend patterns to make predictions and solve problems.

2.9 Measurement. The student recognizes and uses models that approximate standard units (metric and customary) of length, weight, capacity, and time. The student is expected to:
   (A) identify concrete models that approximate standard units of length, capacity, and weight; and
   (B) measure length, capacity, and weight using concrete models that approximate standard units.

2.12 Underlying processes and mathematical tools. The student applies Grade 2 mathematics to solve problems connected to everyday experiences and activities in and outside of school. The student is expected to:
   (A) identify the mathematics in everyday situations;
   (B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;
   (C) select or develop an appropriate problem-solving strategy including drawing a picture, looking for a pattern, systematic guessing and checking, or acting it out in order to solve a problem;
   (D) use tools such as real objects, manipulatives, and technology to solve problems.
2.13 Underlying processes and mathematical tools. The student communicates about Grade 2 mathematics using informal language. The student is expected to:
   (A) explain and record observations using objects, words, pictures, numbers and technology
   (B) relate informal language to mathematical language and symbols.

2.14 Underlying processes and mathematical tools. The student uses logical reasoning to make sense of his or her world. The student is expected to reason and support his or her thinking using objects, words, pictures, numbers, and technology.

Art TEKS

2.1 Perception. The student develops and organizes ideas from the environment. The student is expected to:
   (A) identify variations in objects and subjects from the environment, using the senses; and
   (B) identify color, texture, form, line, and emphasis in nature and in the human-made environment.

2.2 Creative expression/performance. The student expresses ideas through original artworks, using a variety of media with appropriate skill. The student is expected to:
   (C) identify and practice skills necessary for producing drawings, paintings, prints, constructions, and modeled forms, using a variety of materials.
Social Studies TEKS

4.18 Social studies skills. The student communicates in written, oral, and visual forms. The student is expected to:
   (A) express ideas orally based on knowledge and experiences; and
   (B) create written and visual material such as stories, poems, maps, and graphic organizers to express ideas.

4.19 Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings. The student is expected to:
   (A) use a problem-solving process to identify a problem, gather information, list and consider options, consider advantages and disadvantages, choose and implement a solution, and evaluate the effectiveness of the solution; and
   (B) use a decision-making process to identify a situation that requires a decision, gather information, identify options, predict consequences, and take action to implement a decision.
Reading Connections

The following books are recommended as literary resources for teachers to share with fourth grade students. Teachers are cautioned, however, to remember that “reading about science” is not “doing science.” These books can enhance students' study of measuring the properties of matter but cannot replace the learning that occurs by active engagement in the learning experiences.

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(ISBN 0-689-83521-3)

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