# Mastering metrics

By the time students reach a middle school science course, they are expected to make measurements using the metric system. However, most are not practiced in its use, as their experience in metrics is often limited to one unit they were taught in elementary school. This lack of knowledge is not wholly the fault of formal education. Although the metric system has been around since the 1600s and its use was made legal in the United States in 1866, most U.S. residents are not proficient with it. It is usually necessary to re-teach the metric system before students can collect and report data in scientific terms.

I introduce the metric system by giving students an oral quiz. I give them categories for each question and then ask for volunteers. For example, the first question might be, "Who thinks they know how tall they are?" I usually pick a student who is close to 6 feet tall to answer this question. Then I ask him or her, "Which measure best describes the height of a person who is 6 feet tall: 1 league, 1 fathom, 1 rod, or 1 furlong?" Students are at first taken aback by such a line of questioning, but then rise to the challenge and want to figure it out. Some of the questions that I pose to students are listed below, along with correct answers (denoted by asterisks) and conversions are in parentheses. You could also provide the questions to students on a handout and they could do research online or in the library to find the answers.

1 How tall is a 6 foot person?
a. 1 league (15,840 feet)
b.* 1 fathom (6 feet)
c. 1 rod (16.5 feet)
d. 1 furlong (5,282 feet )

2. How much milk is in a gallon jug?
a. 2 pints (1/4 gallon)
b. 2 quarts (1/2 gallon)
c. 5 pecks (2 gallons)
d.* 32 gills (1 gallon)

3. How much does a quarter-pound burger weigh before cooking?
a.* 1,750 grains (1/4 lb)
b. 128 drams (1/2 lb)
c. 8 ounces (1/2 lb)
d. 1 hundredweight (100 lbs)

4. How much does your average 2.5 gram penny weigh?
a. 47 apothecaries' drams (12 grams)
b.* 39 grains (2.5 grams)
c. 20 scruples (15 grams)
d. 1 pennyweight (1.5 grams)

5. At what temperature does water freeze?
a. 0° Fahrenheit (–18°C)
b.* 492° Rankine (0°C)
c. 32° Celsius (32°C)
d. 100 Kelvin (–173°C)

After the not-so-metric measurement quiz, it is usually apparent to students that a vast array of measurement units are used in the English language. To add to the confusion, I inform them that although their car may hold 20 gallons of gas in the United States, if they drove to Canada it would only hold 16.59 Canadian gallons. This illustrates that sometimes even the same unit means different things. We discuss how a U.S. short ton equals 2,000 pounds, a U.S. long ton equals 2,240 pounds, a nautical ton equals 100 cubic feet, and a freight ton equals 40 cubic feet; so although *ton* can be an ambiguous term, there is little ambiguity in *kilometer* and other metric units.

As a follow-up to the quiz, I ask students to define *ton* and provide a variety of resources for students to look in (that have different definitions). When students return with their researched answers, they have differing definitions of *ton*, which leads them to their next quest, to find the history of the ton measurement. Once students find out the history of the ton, they realize that there are several different types of tons used for different things.

I also ask students to investigate the history of measurement in general and to report on early measurement units and tools used by ancient peoples. Students find that early humans used all sorts of readily available items (including rocks, body parts, and so on) to standardize measurement.

After teaching students about the units that are used in scientific measurement, I have them build the metric box (Figure 4). The metric box is a small paper cube that students measure, cut, fold, and tape. Students practice measuring and recording lengths and then represent those collective lengths graphically and numerically. The metric box is an exercise in following directions, making metric measurements, and collecting and displaying data.

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## Metric box

**Materials (per student)**

Scissors, tape, metric ruler, pencil, Metric Box Cutout

1. On the Metric Box Cutout on page 55, connect the dots as indicated below using a ruler and a pencil. As you connect the dots, measure their length in centimeters and write the length in the appropriate place in the table. Round your measurements to the nearest whole number.

| Points to connect | Length (cm) | Points to connect | Length (cm) | Points to connect | Length (cm) |
|---|---|---|---|---|---|
| AO | | NP | | IK | |
| AB | | PQ | | 3C | |
| CD | | RZ | | MO | |
| DE | | RS | | MN | |
| FG | | ST | | XY | |
| FL | | TU | | JX | |
| GH | | UW | | B2 | |
| HI | | WY | | 23 | |

2. Count the number of lines you drew that were 1 cm long. Record your answers in the table below. Do the same for lines that were 2 cm long, 3 cm long, and so on. Using a piece of graph paper, represent your results as a bar graph. Label both axes of your graph appropriately.

**What percentage were:**

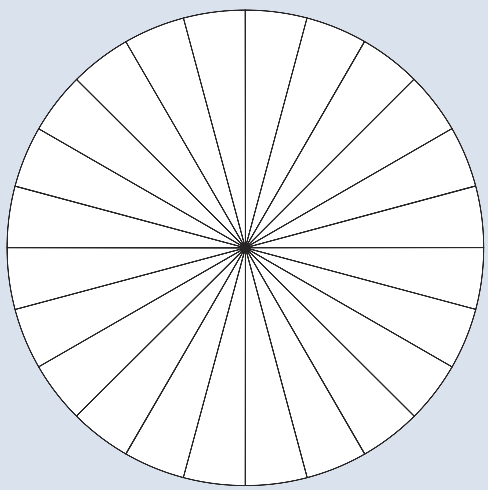
(answers in parentheses)

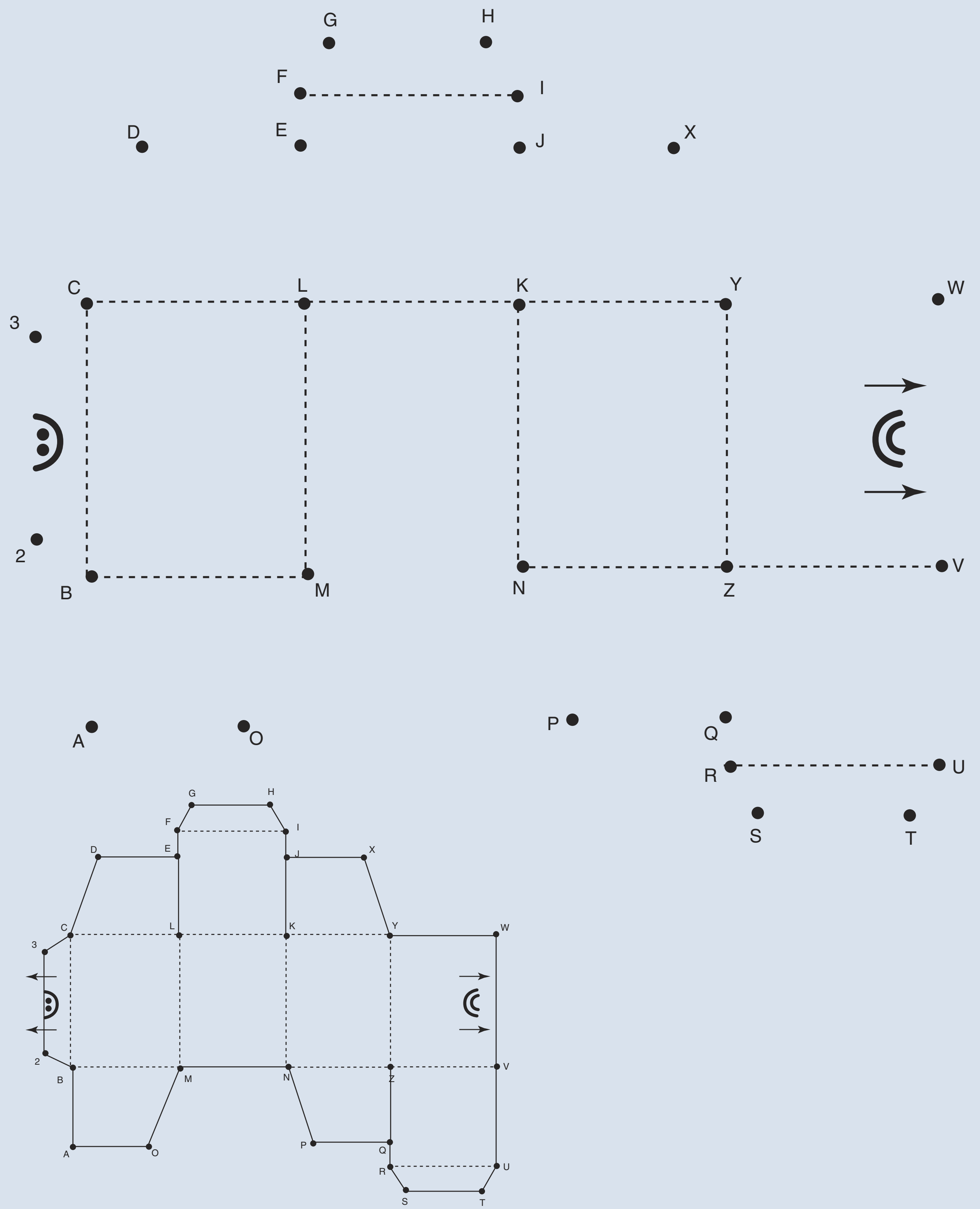
1 cm long?______ 6 cm long? ______
2 cm long?______ 7 cm long? ______
3 cm long?______ 8 cm long? ______
4 cm long?______ 9 cm long? ______
5 cm long?______

5. Assemble the box
   A. Remove the shape you have just drawn by cutting along the solid black lines. You'll need to make three additional cuts along segments JK, EL, and QZ to free up some flaps and cube faces.
   B. Fold the paper lengthwise along the four parallel dotted lines to form the body of the cube. Tape together the two halves of the smiley face, one on a small flap and the other on a cube face, to hold the cube together.
   C. Fold the four remaining flaps in place, two on each of the remaining sides, and seal the cube by folding down the two final cube faces and taping them in place. The tape allows the box to be reopened and things to be placed inside for studies of density.
6. Please tape your completed box to this page.

| Length | 1 cm | 2 cm | 3 cm | 4 cm | 5 cm | 6 cm | 7 cm | 8 cm | 9 cm |
|---|---|---|---|---|---|---|---|---|---|
| Number of lines | | | | | | | | | |

3. The pie chart on the right is divided into 24 segments. Each segment represents one of the 24 lines you drew when connecting the dots. Choose a color to represent each length that you drew. On the pie chart, use that color to shade in the number of segments that corresponds to the number of lines drawn for each length. Create a legend that explains what each color represents.
4. Count the number of segments you shaded in for each color. Divide that number by 24 to give you the percentage of segments represented in the pie chart.

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