

Lesson 1: Linear Measurement



Selected Content Standards

Benchmarks Addressed:

- M-1-M** *Applying the concepts of length, area, surface area, volume, capacity, weight, mass, money, time, temperature, and rate to real-world experiences*
- M-4-M** *Using intuition and estimation skills to describe, order, and compare formal and informal measures (e.g., ordering cup, pint, quart, gallon; comparing a meter to a yard)*
- M-6-M** *Demonstrating the connection of measurement to the other strands and to real-life situations*
- M-1-H** *Selecting and using appropriate units, techniques, and tools to measure quantities in order to achieve specified degrees of precision, accuracy, and error (or tolerance) of measurements*

GLEs Addressed:

Grade 6

18. Measure length and read linear measurements to the nearest sixteenth-inch and mm (M-1-M)

Grade 7

21. Compare and order measurements within and between the U.S. and metric systems in terms of common reference points (e.g., weight/mass and area) (M-4-M) (G-1-M)

Grade 8

30. Construct, interpret, and use scale drawings in real-life situations (G-5-M) (M-6-M) (N-8-M)

Grade 9

17. Distinguish between precision and accuracy (M-1-H)
18. Demonstrate and explain how the scale of a measuring instrument determines the precision of that instrument (M-1-H)

Lesson Focus

This lesson is intended as an introduction to measurement. It includes the following:

- Using a ruler
- Accuracy of measurement
- Benefits of using English & Metric units
- Connection between inch/centimeter and yard/meter
- Use of scale in a scale drawing

GEE 21 Connection

The skills that will be addressed in this lesson include the following:

- Measure length and read linear measurement units accurately to the nearest millimeter or sixteenth of an inch
- Understand numerical relationships among units within each system (customary and metric)
- Demonstrate an understanding of accuracy and precision

Translating Content Standards into Instruction

- A. The first thing we want students to understand is how a ruler is used, how it is read, and how the number of subdivisions on a particular ruler affects its precision.
1. Show students various rulers with different degrees of precision (see attached ***Teacher Blackline #1***). Students should understand that the more marks that a measuring instrument has, the more precise the reading can be. Explain that the accuracy of a measurement depends on how close the measurement is to the actual or true measurement.
 2. Connect the number of marks a ruler has with its fractional part of the desired unit (i.e., if an inch is separated into sixteen parts, then each part is a sixteenth of an inch)
 3. Show students the proper way to use a standard ruler, how to read it, etc. Make sure students know that every measurement has two things: an amount (number) and a unit of measure (label).
 4. Have students measure the line segments on the worksheet provided (***Student Worksheet #1***), and then talk about the results as a class.
 5. Help students understand that measurement is an approximation and has some error associated with it.
- B. Talk to students about the two different systems that we use in measurement — U. S. and Metric. We want students to fully appreciate what makes the Metric system more “user friendly” and that in the rest of the world, it is the preferred system of measurement.
1. Explain how the United States is one of only a couple of countries in the world that actually still uses the U.S. (English) system of measurement.
 2. Have students explain why they think the metric system is so popular with the rest of the world (connect it with our base ten system).
 3. Students should understand that a millimeter is “1/1000 of a meter” and a centimeter is “1/100 of a meter.” They should use this when making conversions. Also, students need to “see” that it takes 10 millimeters to make 1 centimeter. This should all be explained by getting students to look at an actual meter stick.
 4. Using the worksheet provided (***Student Worksheet #1***), have students measure the same line segments using a metric ruler. Have students write their measurements in millimeters, centimeters, and meters. Talk with the class about the results.

- C. Talk with students about the way in which we can easily convert between the two systems of measurement—not by writing the conversions on a chart, but rather by actually looking at rulers and meter-sticks to make the comparisons between units.
1. Have students draw an inch-long line segment. Have them measure the segment using the centimeter ruler. Students should “see” that an inch is about $2\frac{1}{2}$ centimeters. This information can be useful when going from one system to the other.
 2. Ask the students to compare the lengths of a meter-stick and a yardstick. Students should “see” that a meter is a little longer than a yard (about 3 inches longer).
 3. Write down the two comparisons and have students use this information when conversions are necessary between the two systems of measurement.

“An inch is about $2\frac{1}{2}$ centimeters”

“A meter is a little longer than a yard—about 3 inches longer”

- D. Talk with students about scale, about how scale drawings are used in real-life, and about how measurements are affected when a scale is being used.
1. Explain to students how maps operate, show them a map, and talk about the scale the map is using and how the scale can be used to find distances on a map.
 2. Provide students with ***Student Worksheet #2***. Let the students work in small groups to complete the activity, then talk about the results as a whole class.
 3. As an enrichment activity have students use a map to find distances.

GEE 21 Connection

On the GEE 21 test, students may be required to measure using a ruler, compare metric/U.S. (English) units, have a conceptual understanding of various types of measurement, and use a scale drawing to obtain information to answer various questions.

Sources of Evidence about Student Learning

- A. Have students measure various objects around the school or room in both English and metric units. Include objects that vary in length from very small (where inch/centimeter would be appropriate unit of length) to very large (where feet/yards would be the appropriate unit of length).
- B. Have students do student worksheets provided with the lesson.
- C. As an additional source of student work, you may want the students to design a scale-drawing activity themselves, along with appropriate questions. The teacher should then select the best work to give to the class as supplementary work.

GEE 21 Connection

See attachment at the end of the Measurement Lessons for sample questions related to the GEE 21.

Attributes of Student Work at the “Got-It” level

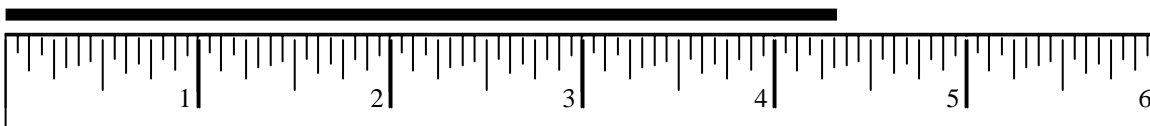
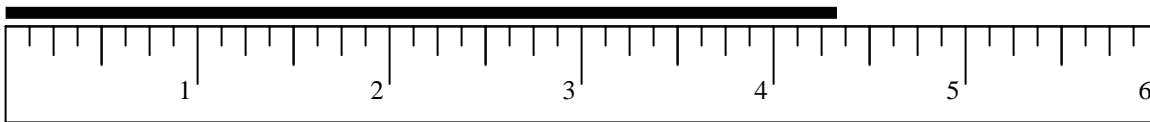
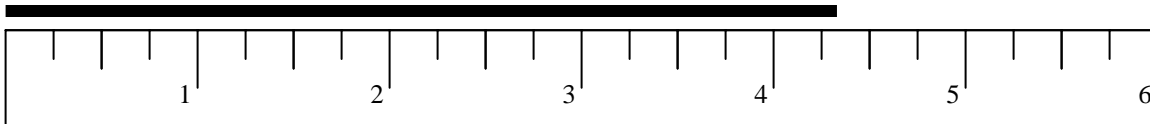
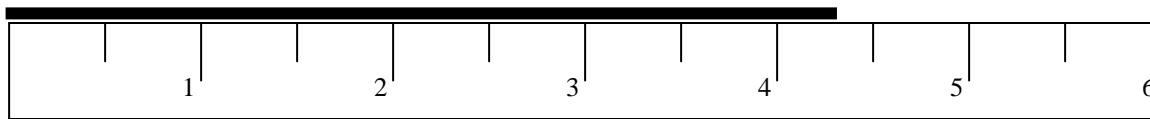
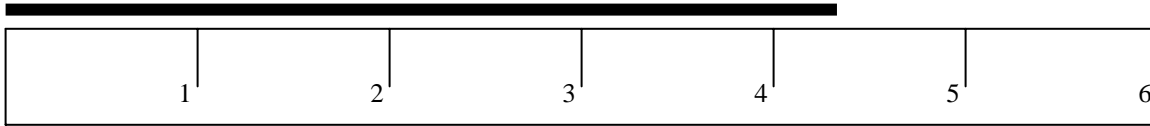
- A. When students are making their measurements for the items that are in the room or around the school, make sure that all students are within an acceptable range in their measurements (i.e., fairly accurate). Any student or group that is outside the acceptable range should be required to “re-measure” the item to make sure that the error being made is corrected.

- B. When reviewing student work on the provided worksheets, allow students to work alone first, then provide time to allow for students to compare their answers in groups. Let the students talk about how they got their answers, and if there were any discrepancies between group members, have the members explain what they did to clear up any differences. Make sure that all students are within an acceptable range when writing down a measurement, but all students must understand that measurement is not an exact science—we are only getting an approximation within a certain degree of precision depending on the measurement tool we are using.

How long is this line segment?



Use the rulers shown to find the segment length, then answer the questions below.




Questions for students:

- (a) Which ruler do you think is going to provide the most precise measurement? Why?
- (b) What degree of precision is each of the rulers going to provide?
- (c) For each ruler, identify the number of sections into which each inch is divided.
- (d) Write the measurement of the line segment next to each ruler. Your answer should be based on the closest mark to the end of the segment.
- (e) Is there such a thing as an “exact measurement?” Explain.

Directions: Use your rulers to measure each of the following segments to the nearest $\frac{1}{16}$ of an inch. Make your measurements as accurately as you can. After all measurements are made, compare your answer to other students in your group. A class discussion of the findings will follow.

1. ----- 

2. ----- 

3. ----- 

4. ----- 

5. ----- 

6. ----- 

7. ----- 

8. ----- 

9. ----- 

10. ----- 

1. The map below shows several places on a map. It is drawn to scale, which means that for every so many units long on the map, we get so many units long in real life. For our map, we used the following scale: $\frac{1}{16}$ inch represents 6 miles. Use this scale and your ruler to answer the following questions.

Burger Magic

Wal Mall

School

Movie
Theater

Pizza Café

- (a) How far is it from Wal Mall to the School on the map? _____
(measured distance, not actual distance)
- (b) How many “sixteenths” are in every inch? _____
- (c) How many miles does each inch represent? _____
Explain your reasoning.
- (d) How many “sixteenths” of an inch are in the measurement you made in question (a)? _____
- (e) How far in “real-life” is it from Wal-Mall to School?
_____ How did you determine this?
- (f) Do you think the places on the map are in the same town? Explain how you know.
- (g) Which is closer to the Pizza Café—Wal Mall or School?
_____ How much closer is it? _____
Show what you did to figure this out.

- (h) Fill out the following table which shows the measured and actual real-life distances from one place to another on the map.

Starting Point	Destination	Measured Distance (in)	Actual Distance (miles)
School	Wal Mall		
Burger Magic	Movie Theater		
School	Burger Chef		

- (i) Using the table you made, if someone traveled from School to Burger Magic, then from Burger Magic to the Movie Theater, how far would he/she have traveled?

- (j) Gas costs \$1.19 a gallon. If the car used to travel in this problem holds 12 gallons of gas and gets 24 miles per gallon, how much would it cost to fill the gas tank?

 How many miles could the car travel before needing a fill-up? -----
 Explain how you got both answers.

- (k) There is an historical monument 60 miles south of Burger Magic. Draw where the monument is located. Label it on the map. How far away, in inches, is the monument on the map? ----- Explain how you determined this.

Teacher Blackline #1

Questions for Students:

- (a) The most precise ruler will be the ruler that has the most marks per inch. In this case, it is the last ruler which is precise to the nearest sixteenth inch.
- (b) The precision depends on the ruler used and the number of marks it has.
- Ruler #1—can measure to the nearest inch
 - Ruler #2—can measure to the nearest half-inch
 - Ruler #3—can measure to the nearest fourth-inch
 - Ruler #4—can measure to the nearest eighth-inch
 - Ruler #5—can measure to the nearest sixteenth-inch
- (c) The number of parts into which each inch is separated depends on the ruler.
- Ruler #1—inches are in whole parts
 - Ruler #2—inches are in two parts
 - Ruler #3—inches are in four parts
 - Ruler #4—inches are in 8 parts
 - Ruler #5—inches are in 16 parts
- (d) The ruler used will determine the measure:
- Ruler #1—4 inches
 - Ruler #2—4 $\frac{1}{2}$ inches
 - Ruler #3—4 $\frac{1}{4}$ inches
 - Ruler #4—4 $\frac{3}{8}$ inches
 - Ruler #5—4 $\frac{5}{16}$ inches
- (e) There is no such thing as an “exact” measurement because there is always some error associated with it. The error depends upon the accuracy of the tool being used to measure (i.e., are the inch markings reflective of the actual length of an inch, is a 1-foot ruler really 1 foot in length) and human error.

Student Worksheet #1

*Answers may vary, so these measurements should be close in proximity.

English	Metric
1. 4 $\frac{6}{16}$ inches or 4 $\frac{3}{8}$ inches	1. 111 mm or 11.1 cm or 0.111 m
2. 10/16 inch or 5/8 inch	2. 15 mm or 1.5 cm or 0.015 m
3. 3 $\frac{9}{16}$ inches	3. 91 mm or 9.1 cm or 0.091 m
4. 3/16 inch	4. 5 mm or 0.5 cm or 0.005 m
5. 2 $\frac{1}{16}$ inches	5. 53 mm or 5.3 cm or 0.053 m
6. 2 $\frac{13}{16}$ inches	6. 71 mm or 7.1 cm or 0.071 m
7. 1 $\frac{10}{16}$ inches or 1 $\frac{5}{8}$ inches	7. 40 mm or 4 cm or 0.04 m
8. 4 $\frac{13}{16}$ inches	8. 122 mm or 12.2 cm or 0.122 m
9. 3 $\frac{1}{2}$ inches	9. 88 mm or 8.8 cm or 0.088 m
10. 5 $\frac{11}{16}$ inches	10. 144 mm or 14.4 cm or 0.144 m

Student Worksheet #2

1. All answers are approximations.
- $4 \frac{3}{16}$ inches (approximately)
 - There are 16 “sixteenths” in each inch
 - Each inch represents 96 miles (since each sixteenth is 6 miles, and there are 16 sixteenths in each inch, then each inch represents $6 \times 16 = 96$ miles)
 - In the measurement, there are actually 4 whole inches ($4 \times 16 = 64$ sixteenths) plus an additional 3 sixteenths, giving a total of 67 sixteenths.
 - From Wal Mall to School, it is a total distance of 402 miles. One way of finding the answer is to realize that each inch represents 96 miles, so if we have 4 whole inches, you get four groups of 96 miles: $96 \text{ miles} + 96 \text{ miles} + 96 \text{ miles} + 96 \text{ miles} = 384 \text{ miles}$, plus you have an additional $\frac{3}{16}$ where each sixteenth inch is 6 miles each, giving an additional 18 miles. If we total up the number of miles we would get $384 \text{ miles} + 18 \text{ miles} = 402 \text{ miles}$. There are of course many ways to get this answer and all the different ways students figured this out should be thoroughly discussed.
 - The places shown in the map are not in the same town because they are obviously too far apart.
 - Wal Mall is closer. It is $2 \frac{1}{16}$ inches from the Café while the school is $2 \frac{7}{16}$ inches from the Café. Therefore, it is $\frac{6}{16}$ inches closer, which is a distance of 36 miles closer in real life.
 - The table is filled out below.

Starting Point	Destination	Measured Distance (in)	Actual Distance (miles)
School	Wal Mall	$4 \frac{3}{16}$ in	402 miles
Burger Magic	Movie Theater	$2 \frac{13}{16}$ in	270 miles
School	Burger Magic	$2 \frac{1}{2}$ in	240 miles

- 510 miles
- It would cost \$14.28 to fill up the tank (if it were empty, of course). The car could travel a total distance of 288 miles before it needed a fill-up. How students get these answers may vary.
- The monument should be a distance of $\frac{10}{16}$ on the map and should be located directly south of Burger Magic. Explanations may vary.