1.6 Use Precision and Measurement

Key Vocabulary
• precision
• significant digits

COMMON CORE

CC.9-12.N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.*

You ask two friends for the time. Noah says that it is about 2:30. Mia says it is 2:28 and 19 seconds. Mia gives a more *precise* measurement of the time.

Noah's Watch

Mia's Watch 02:28:19

PRECISION Precision is the level of detail that an instrument can measure. Mia's watch is more precise than Noah's watch because it gives the time to the nearest second. In a similar way, a ruler marked in millimeters is more precise than a ruler marked only in centimeters, since a millimeter is a smaller unit than a centimeter.

EXAMPLE 1 Compare precision of measurements

Choose the more precise measurement.

a. 7 cm; 7.3 cm   **b.** 5 yd; 16 ft   **c.** 1 pint; 16 ounces

Solution

AVOID ERRORS
Remember that the smaller number is not always the more precise measurement. Always examine the units of measure.

**a.** The units are the same. Because tenths are smaller than ones, 7.3 centimeters is more precise than 7 centimeters.

b. The units are different. Because a foot is a smaller unit of measure than a yard, 16 feet is a more precise unit of measure.

c. The units are different. Because an ounce is a smaller unit of measure than a pint, 16 ounces is a more precise measurement even though 1 pint is equal to 16 ounces.

✓ **GUIDED PRACTICE** for Example 1

Choose the more precise measurement.

1. 21.13 oz; 21.4 oz

2. $14\frac{1}{2}$ in.; $2\frac{5}{8}$ in.

3. 14 mm; 2 cm

4. 2.5 hr; 90 min

SIGNIFICANT DIGITS To the nearest centimeter, the diameter of a United States quarter is 2 centimeters. Measured to the nearest millimeter, the diameter of the quarter is 24 millimeters. The measurement 24 millimeters is more precise because it is given using a smaller unit of length.
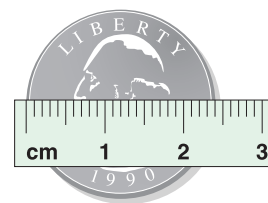
In the two coin measurements, notice that the numerical value 24 has more digits than the value 2. You can use the number of significant digits to describe the precision of a measurement. **Significant digits** are the digits in a measurement that carry meaning contributing to the precision of the measurement.

KEY CONCEPT   *For Your Notebook*

Determining Significant Digits

Rule	Example	Significant digits	Number of significant digits
All nonzero digits	281.39	**281.39**	5
Zeros that are to the right of both the last nonzero digit and the decimal point	0.0070	0.00**70**	2
Zeros between significant digits	500.7	**500.7**	4

Zeros at the end of a whole number are usually assumed to be nonsignificant. For example, 220 centimeters has 2 significant digits, while 202 centimeters has 3 significant digits.

EXAMPLE 2   Identify significant digits

Determine the number of significant digits in each measurement.

   a. 290.01 g   **b.** 0.8500 km   **c.** 4000 mi

Solution

   a. The digits 2, 9, and 1 are nonzero digits, so they are significant digits. The zeros are between significant digits, so they are also significant digits.

   There are 5 significant digits: **290.01**.

   b. The digits 8 and 5 are nonzero digits, so they are significant digits. The two zeros to the right of the last nonzero digit are also to the right of the decimal point, so they are significant digits.

   There are 4 significant digits: 0.**8500**.

   c. The digit 4 is a nonzero digit, so it is a significant digit. The zeros at the end of a whole number are not significant.

   There is 1 significant digit: **4**000.

AVOID ERRORS
Remember that not all zeros are significant. Be careful when deciding whether a zero in a number is significant or not.

SIGNIFICANT DIGITS IN CALCULATIONS When you perform calculations involving measurements, the number of significant digits that you write in your result depends on the number of significant digits in the given measurements.

KEY CONCEPT		*For Your Notebook*
Determining Significant Digits in Calculations		
Operations	**Rule**	**Example**
Addition and Subtraction	Round the sum or difference to the same place as the last significant digit of the least precise measurement.	3.24 ← hundredths + 7.3 ← tenths **10.5**4 ← tenths
Multiplication and Division	The product or quotient must have the same number of significant digits as the least precise measurement.	40 ← 1 sig digit × 31 ← 2 sig digits 1240 ← exact answer **1000** ← 1 sig digit

EXAMPLE 3   **Calculating with significant digits**

Perform the indicated operation. Write the answer with the correct number of significant digits.

a. 45.1 cm + 19.45 cm   **b.** 6.4 ft × 2.15 ft

Solution

a. 45.1 cm + 19.45 cm = 64.55 cm

The least precise measurement is 45.1 centimeters. Its last significant digit is in the tenths place. Round the sum to the nearest tenth.

The correct sum is 64.6 centimeters.

b. 6.4 ft × 2.15 ft = 13.76 ft^2

The least precise measurement is 6.4 feet. It has two significant digits. Round the product to two significant digits.

The correct product is 14 square feet.

✓ **GUIDED PRACTICE**   **for Examples 2 and 3**

Determine the number of significant digits in each measurement.

5. 800.20 ft   **6.** 0.005 cm   **7.** 36,900 mi

Perform the indicated operation. Write the answer with the correct number of significant digits.

8. 27.23 m − 12.7 m   **9.** 45.16 yd^2 ÷ 4.25 yd

1.6 EXERCISES

SKILL PRACTICE

1. **VOCABULARY** Copy and complete: The level of detail that an instrument can measure is known as its   ? .

2. ★ **WRITING** Which number, 0.023 or 301, has the fewer significant digits? Explain.

EXAMPLE 1
for Exs. 3–10

COMPARING PRECISION Choose the more precise measurement.

3. 14.2 gal; 7 gal
4. 0.02 mm; 0.1 mm
5. 90 ft; 71 in.
6. 57.65 lb; 34.9 lb
7. 14.1 m; 29.3 cm
8. 36 yd; 17.2 yd

ERROR ANALYSIS Describe and correct the error in the statement.

9. Heidi told her friend Mike that 1.5 hours is a more precise measurement of time than 85 minutes.

10. Eric's new fishing rod was advertised as being 4 feet long. He measured it to be 47 inches long. Eric's friend says that 4 feet is the more precise measurement.

EXAMPLE 2
for Exs. 11–20

IDENTIFYING SIGNIFICANT DIGITS Determine the number of significant digits in the measurement.

11. 312.5 cm
12. 100 hr
13. 0.030 gal
14. 16.007 lb
15. 1020 mm
16. 0.0025 sec
17. 38.0 m
18. 8.375 ft
19. 205.7140 mi

20. ★ **MULTIPLE CHOICE** The measurement 0.007 grams contains how many significant digits?

Ⓐ 1   Ⓑ 2   Ⓒ 3   Ⓓ 4

EXAMPLE 3
for Exs. 21–30

CALCULATING WITH SIGNIFICANT DIGITS Perform the indicated operation. Write the answer with the correct number of significant digits.

21. 97.2 m − 16.04 m
22. 8 ft × 11.2 ft
23. 257.64 oz ÷ 2.4 oz
24. 0.043 yd + 0.22 yd
25. 6.42 mm × 7.51 mm
26. 2.8 mi + 3.56 mi
27. 245 kg − 18.32 kg
28. 9.05 cm^2 ÷ 18 cm

29. ★ **WRITING** Describe how to find the number of significant digits to give for the area of a rectangle with side lengths 8.2 meters and 20 meters.

30. ★ **MULTIPLE CHOICE** The quotient 97.3 hr ÷ 5.5 hr contains how many significant digits?

Ⓐ 4   Ⓑ 3   Ⓒ 2   Ⓓ 1

CHALLENGE Perform the indicated operation. Write the answer with the correct number of significant digits.

31. 0.40 ft × 2.25 ft
32. 23.175 km^2 ÷ 10.30 km

EXAMPLE 1
for Exs. 33–36

33. COINS According to the United States Mint, a one-dollar coin has a mass of 8.1 grams. Justine finds the mass of a one-dollar coin and reports a mass of 8.05 grams. Steven finds that the mass of his one-dollar coin is 8.2 grams. Whose measurement is more precise?

COMPARING MEASUREMENTS For Exercises 34–36, three students are asked to measure a piece of string that has a length of exactly 15.2 centimeters. Their measurements are shown in the table.

Student	Measurement
Alex	15.35 cm
Chandra	14.9 cm
Luis	154 mm

34. Which student made the most precise measurement?

35. Which student made the least precise measurement?

36. Which student's answer is closest to the actual length of the string?

**EXAMPLES
2 and 3**
for Exs. 37–47

37. ★ **SHORT RESPONSE** Brian drives 426 miles and uses 19.3 gallons of gas for the trip. Brian's calculator shows that $\frac{426}{19.3} \approx 22.07253886$, so he states that his car gets 22.07253886 miles per gallon. Do you agree with Brian's statement? *Explain* your answer.

38. REFLECTING POOL The Reflecting Pool is a rectangular body of water in front of the Lincoln Memorial in Washington, D.C. A surveyor determines that the length of the pool to the nearest foot is 2029 feet and the width of the pool to the nearest foot is 167 feet.

  a. How should the surveyor report the perimeter of the pool using the correct number of significant digits?

  b. How should the surveyor report the area of the pool using the correct number of significant digits?

39. HEALTH When Kyle went for his annual physical the nurse weighed him and told him he weighed 118.5 pounds. After seeing the doctor, Kyle was sent for some tests where he was weighed again. This time he was told he weighed 119 pounds. Which of the two measurements is more precise? *Explain* your answer.

40. GARDENING A student measures the length of a rectangular garden plot to the nearest tenth of a meter and finds that the length is 6.4 meters. Another student measures the width of the plot to the nearest meter and finds that the width is 2 meters. Using the correct number of significant digits, what are the perimeter and area of the plot?

41. CHARITY RUN Nicole and Renee are participating in a charity run to raise money for their school's library. Both girls have sponsors who will pay them $1 for each mile they collectively run. If Nicole ran 7.2 miles and Renee ran 6.03 miles, how should they report their cumulative miles to their sponsors using the correct number of significant digits?

★ **OPEN-ENDED** In Exercises 42–46, give an example of the described measurement.

42. A 5-digit distance in miles that has 3 significant digits

43. A measurement greater than 1000 centimeters that has 2 significant digits

44. A measurement less than 1 millimeter that has 4 significant digits

45. A 4-digit area that has 3 significant digits and 2 digits that are zeros

46. A weight less than 10 pounds that has 5 significant digits

47. POSTERS The area of a rectangular poster is 852 square inches. The length of the poster is 36 inches. Using the correct number of significant digits, what is the width of the poster?

48. SCIENCE Tanya and Edmond are lab partners in science class. They each measure the volume of a beaker of a solution. Tanya found the volume to be 2.25 liters, while Edmond reported the volume as 2300 milliliters. Who gave the more precise measurement? *Explain* your answer.

49. REALTORS When a realtor first lists a home for sale, it is very important to calculate the living area of the home. Carrie measured the length and width of a house she is about to list and found that it measured 52.5 feet long by 35 feet wide. Using the correct number of significant digits, how should Carrie report the area of the house?

50. CHALLENGE A student measures the length of a cube and records the length as 3.5 centimeters. Using the correct number of significant digits, how should the student report the volume of the cube?

51. CHALLENGE Suppose the average 12-ounce aluminum drink can weighs approximately 13.6 grams and the liquid inside weighs approximately 453.59 grams. Using the correct number of significant digits, how much do the 24 drink cans in a carton weigh?