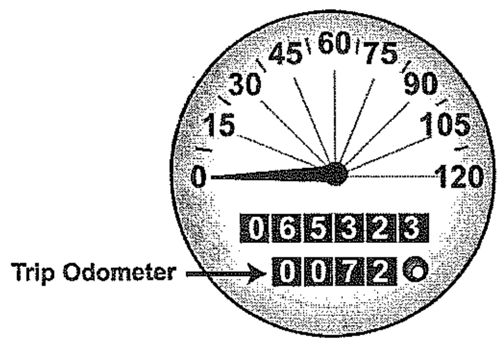
Name: Answers Date: ________

1.3 Significant Digits

READ

Francisco is training for a 10-kilometer run. Each morning, he runs a loop around his neighborhood. To find out exactly how far he's running, he asks his older sister to drive the loop in her car. Using the car's trip odometer, they find that the route is 7.2 miles long.

To find the distance in kilometers, Francisco looks in the reference section of his science text and finds that 1.000 mile = 1.609 kilometers. He multiplies 7.2 miles by 1.609 km/mile. The answer, according to his calculator, is 11.5848 kilometers.



Francisco wonders what all those numbers after the decimal point really mean. Can a car odometer measure distances as small as 0.0008 kilometer? That's a distance less than one meter!

This skill sheet will help you answer Francisco's question. It will also help you figure out which digits in your own calculations are significant.

What are significant digits?

Significant digits are the ***meaningful*** digits in a measured quantity. Scientists have agreed upon a number of rules to determine which numbers in a measurement are significant. The rules are:

1. **Non-zero digits in a measurement are always significant.** This means that the distance measured by the car odometer, *7.2 miles*, has two significant digits.

2. **Zeros between two significant digits in a measurement are significant.** This means that the measurement of kilometers per mile, *1.609 kilometers*, has four significant digits.

3. **All final zeros to the *right* of a decimal point in a measurement are significant.** This means that the measurement *1.000 miles* has four significant digits.

4. **If there is no decimal point, final zeros in a measurement are NOT significant.** This means that the number 20 in the phrase "20-liter water cooler" has one significant digit. The water cooler isn't marked off in 1-liter increments, so no measurement decision was made regarding the ones place.

5. **A decimal point is used after a whole number ending in zero to indicate that a final zero IS significant.** If you measure 100 grams of lemonade powder to the nearest whole gram, write the number as 100. grams. This shows that your measurement has three significant digits.

6. **In a measurement, zeros that exist only to put the decimal point in the right place are NOT significant.** This means that the number *0.0008* in the phrase "*0.0008 kilometer*" has one significant digit.

7. **A number that is found by *counting* rather than *measuring* is said to have an infinite number of significant digits.** For example, the race officials count 386 runners at the starting line. The number *386*, in this case, has an infinite number of significant digits.

MATH

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PRACTICE

Find the number of significant digits

Table 1: Number of Significant Digits

Value	How many significant digits does each value have?
a. 36.33 minutes	4
b. 100 miles	1 (zeros are place keepers) 1×10^2
c. 120.2 milliliters	4
d. 0.0074 kilometers	2 (zeros are place keepers) 7.4×10^{-3}
e. 0.010 kilograms	2 cause 1.0×10^{-2} 2nd zero is measured
f. 300. grams	3 the dot tells you the zeros are captured
g. 42 students	2 or infinite its a whole #

READ

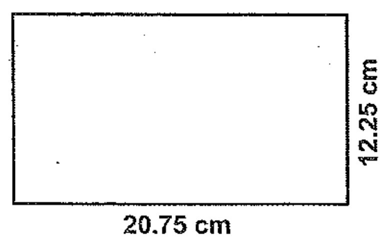
Using significant digits in calculations

Taking measurements and recording data are often a part of science classes. When you use the data in calculations, keep in mind this important principle:

When using data in a calculation, your answer can't be more precise than the least precise measurement.

EXAMPLE

You are using a ruler to measure the length of each side of a rectangle.The ruler is marked in tenths of a centimeter. This means that you can estimate the distance between two 0.1 cm marks and make measurements that are to two places after the decimal.



You measure the two short sides of the triangle and find that they each have a length of 12.25 cm. The long sides each have a length of 20.75 cm.

The rectangle's perimeter (distance around) is 12.25 cm + 20.75 cm + 12.25 cm + 20.75 cm, or 66.00 cm. The two zeros to the right of the decimal point show that you measured with a precision of 0.01 cm.

The area of the rectangle is found by multiplying the length of the short side by the length of the long side.

$$12.25 \text{ cm} \times 20.75 \text{ cm} = 254.1875 \text{ cm}^2$$

The answer you get from you calculator has seven significant digits. This incorrectly implies that your ruler can measure to one ten-thousandth of a centimeter. Your ruler can't measure distances that small!

MATH 1.3

Follow these steps for determining the right answer for your calculation:

- When multiplying or dividing measurements, find the measurement in the calculation with the least number of significant digits. After doing your calculation, round the answer to that number of significant digits.
  In the rectangle example on the previous page, each measurement has 4 significant digits. When you multiply the measurements to find the area, your answer should be rounded to four significant digits. The area should be reported as 254.2 cm^2.

- When adding or subtracting measurements, the answer must not contain more decimal places than your least accurate measurement.
  In the rectangle example, the perimeter is reported to two decimal places to show that your ruler measures length to the nearest 0.01 centimeter.
  It is important to note that when adding or subtracting, you are not concerned with the number of significant digits to the left of the decimal point. When adding 1.25 cm + 1,000.50 cm + 2,000,000.75 cm, the answer is 2,001,002.50 cm. It is okay to have an answer with nine significant digits, because only TWO of them are to the right of the decimal point.

- When you are finding the average of several measurements, remember that numbers found by counting have an infinite number of significant digits.
  For example, a student measures the distance between two magnets when their attractive force is first felt. He repeats the experiment three times. His results are: 23.25 cm, 23.30 cm, 23.20 cm.
  To find the average distance, He adds the three times and divides the sum by three. "Three" is the number of times the experiment is repeated.

$$\frac{23.25 \text{ cm} + 23.30 \text{ cm} + 23.20 \text{ cm}}{3} = 23.25 \text{ cm}$$

In this equation, the number 3 is found by counting the number of times the experiment is repeated, not by measuring something. Therefore it is said to have an infinite number of significant digits. That's why the answer has four significant digits, not just one.

PRACTICE

Report your answers with significant digits

Have you ever participated in a road race? The following problems are all related to a road race event. Can you come up with some other problems that you might have to solve if you were running in or volunteering for a road race?

1. The banner over the finish line of a running race is 400. centimeters long and 85 centimeters high. What is the area of the banner?

   $400. \times 85 = 34000 \text{ cm}^2$ (2 Sig Figs)

   or $3.4 \times 10^4 \text{ cm}^2$

.25 l
.3 l
.37 l

2. Heidi stops at three water stations during the running race. She drinks 0.25 liters of water at the first stop, 0.3 liters at the second stop, and 0.37 liters at the third stop. How much water does she consume throughout the race?

   .92 not sure about 1/100 place
   .9 l

3. The race officials want to set up portable bleachers near the finish line. Each set of bleachers is 4.50 meters long and 2.85 meters wide. How many square meters of open ground space do they need for each set?

   4.50 m × 2.85 = 12.825 m² 12.8 m²

4. The race has been held annually for ten years. The high temperatures for the race dates (in degrees Celsius) are listed in the table below. What is the average high temperature for the race day based on the temperatures for the past ten years? Write your answer in the bottom row in the table.

Table 2: Race Day Temperatures for Each Year

Year Number of Race	Race Day Temperature (°C)
1	27.2
2	18.3
3	28.9
4	22.2
5	20.6
6	25.5
7	21.1
8	23.9
9	26.7
10	27.8
Average Temperature	22.5°C

225.2

$\frac{225.2}{10} =$ 22.52

5. **Challenge!** Ji-Sun has participated in the race for the past four years. His times, reported in minutes:seconds, were
   min → 40:30 2430 sec
   43:40 2620 sec
   39:06 2346 sec
   38:52 2332 sec
   What is his average time to complete the race? (Hint: Convert all times to seconds before averaging!)

   total: 9728 sec
   $\frac{9728 \text{ sec}}{4} =$ 2432 sec or 40 min 32 sec

6. Come up with one more problem that uses information that is related to a road race. Write your problem in the space below and come up with the answer. Be sure to write your answer with the correct number of significant digits. You do it!

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