Name _____ Date _____ Period ____

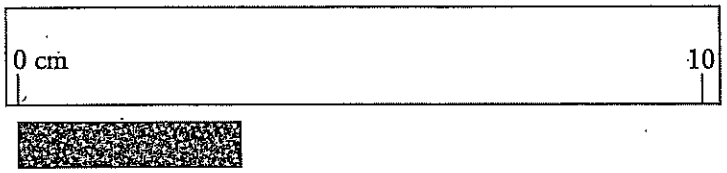
POGIL Introduction to Significant Figures

Why?

Scientists do a lot of measuring. When scientists use an instrument (such as a ruler, graduated cylinder, spectrophotometer or balance) to measure something, it is important to take full advantage of the instrument. However, they can't cheat and record a better measurement than the instrument is capable of. There is an understanding among scientists of the proper way to record valid measurements from any instrument. When you are the scientist, you must record data in this way. When you are reading other scientists' work, you must assume they recorded their data in this way.

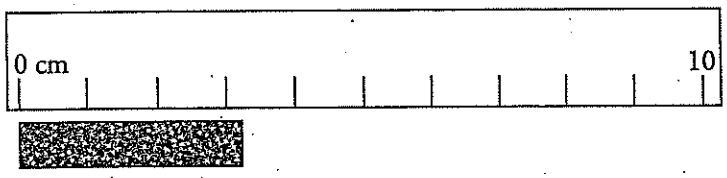
1. What distances can you be certain of on the ruler in Model 1?

Model 1 – Ruler A



Susan	3 cm
Maya	2 cm
Jonah	2.5 cm
Tony	3.00 cm
Emily	3¼ cm
Dionne	3.33 cm

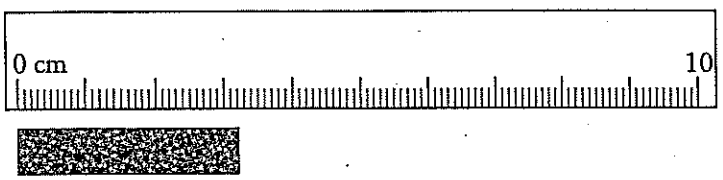
Model 2 – Ruler B



Susan	3.2 cm
Maya	3.1 cm
Jonah	3.3 cm
Tony	3 cm
Emily	3.25 cm
Dionne	3.20 cm

2. The students obtained a better ruler, shown in Model 2. What distances can you be certain of on this ruler?

Model 3 – Ruler C



Susan	3.21
Maya	3.20 cm
Jonah	3.22 cm
Mark	3.2 cm
Emily	3.215 cm
Dionne	3.205 cm

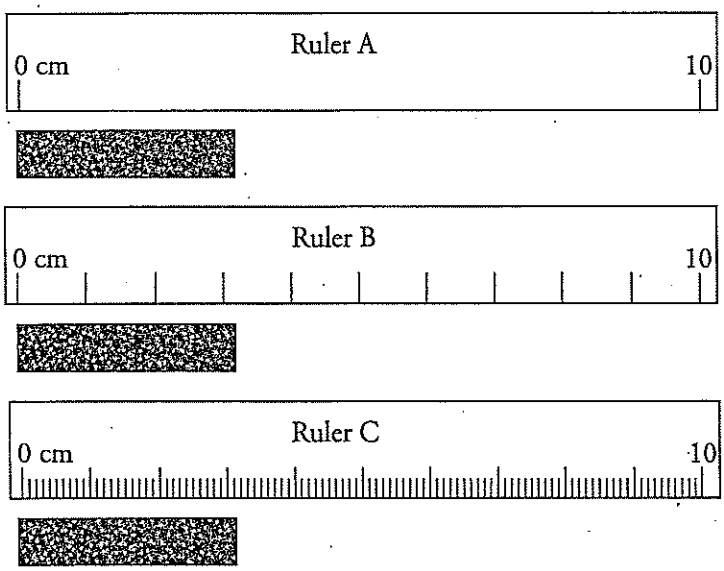
3. The students obtained an even better ruler, shown above in Model 3.

   a. Were the students able to agree on a single value for any of the digits in their measurements using the new ruler? If yes, what value(s) did they agree on in which digits?

Read This!

When humans use measuring instruments, variation is expected. Everyone will estimate differently between marks on the instrument. On the other hand, digits that are certain (based on marks on the instrument) should not vary from person to person.

Model 4 – Valid Measurements



Valid Measurements	Invalid Measurements
3 cm	2.5 cm
2 cm	3.00 cm
	3¼ cm
	3.33 cm
3.2 cm	3 cm
3.1 cm	3.25 cm
3.3 cm	3.20 cm
3.21 cm	3.2 cm
3.22 cm	3.215 cm
3.20 cm	3.205 cm

4. The measurements taken in Models 1–3 have been combined in Model 4. The measurements that follow the rules of measurement agreed upon by scientists are in the "Valid Measurements" column. Those that do not follow the rules are in the "Invalid Measurements" column. For each valid measurement shown in Model 4, yellow highlight the certain digits (if any) and circle the digits that were estimated (if any).

5. Based on the examples in Model 4, circle the best phrase to complete each sentence below.

   a. In a valid measurement, you record (zero, one, two) estimated digit(s).

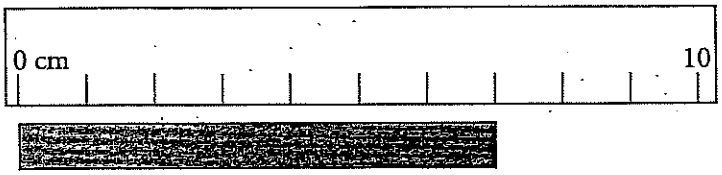
   b. In a valid measurement, the estimated digit is the (first digit, second to last digit, last digit) in the measurement.

STOP

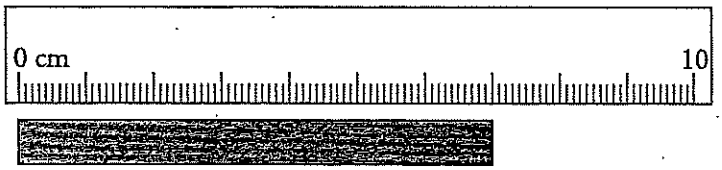
Read This!

When a measurement is recorded properly, all of the digits that are read directly (certain) and one estimated (uncertain) digit are called **significant digits.** The number of allowable significant digits is determined by the marks or gradations of the instrument. Sometimes a "0" is the estimated digit and must be recorded.

6. Record the length of the wooden splint to the proper number of significant digits.

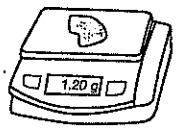


7. Record the length of the wooden splint to the proper number of significant digits.



Extension Questions

8. When using an electronic device, such as an electronic balance, the measurement displayed on the screen is assumed to have one estimated digit included. In fact, you'll often see the estimated digit changing rapidly, because there is fluctuation in the estimate. Explain why it is important to record the zero in the measurement shown to the right.



Significant Zeros

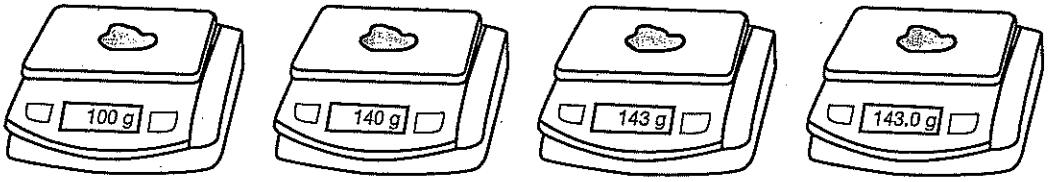
Which zeros are significant in a measurement, and which are simply important?

Why?

When working with measurements, it is important to know which digits in the measurement are significant and which are not. Non-zero digits are always significant. However, zeros can be tricky; some are significant, others are not. This activity will help you learn the rules for determining whether a zero digit is significant or not.

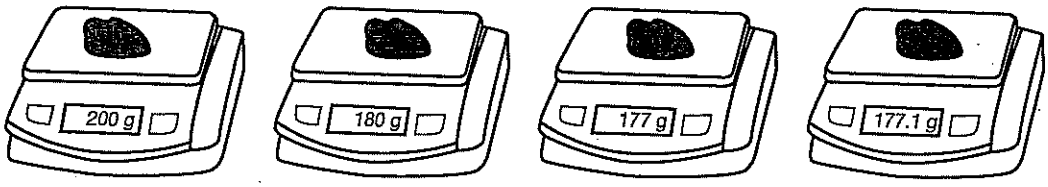
Model 1 – Mass of Rocks

Sample A



Econo-Balance | Good Balance | Balance Pro | Exacto-Balance

Sample B



Econo-Balance | Good Balance | Balance Pro | Exacto-Balance

9. For each balance in Model 1, circle the phrase below that best describes how closely the mass can be determined with that balance.

Econo-Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Good Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Balance Pro	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Exacto-Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g

10. Which of the four balances in Model 1 is the best quality instrument? Explain.

11. Rock C is placed on the Econo-Balance. The balance reads 200 g.

a. Does rock C have a mass larger, smaller or the same as sample A, or is it impossible to tell? Explain your reasoning.

b. Does rock C have a mass larger, smaller or the same as rock B, or is it impossible to tell? Explain your reasoning.

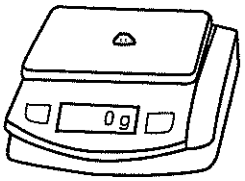
12. The mass of rock C is then measured using the other three balances. The results are shown below.

Econo-Balance	200 g	Balance Pro	177 g
Good Balance	180 g	Exacto-Balance	177.0 g

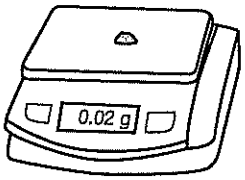
a. Based on this additional information, does rock C have a mass larger, smaller or the same as rock B, or is it impossible to tell? Explain your reasoning.

Model 2 – Mass of Pebbles

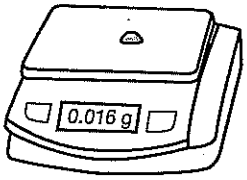
Pebble A



Balance Pro

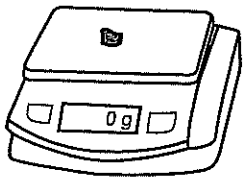


Centi-Balance

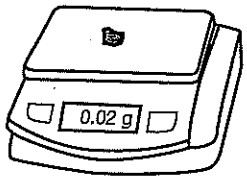


Super Balance

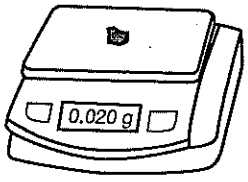
Pebble B



Balance Pro



Centi-Balance



Super Balance

13 For each balance in Model 2, write a phrase to describe how closely the mass of an object can be determined using that balance. The first one is done for you.

Balance Pro: Rounded to the nearest 1 gram.

Centi-Balance:

Super Balance:

14 Pebble A and pebble B both have a mass of 0 g on the Balance Pro in Model 2. Do these pebbles really have no mass? If no, explain why the balance has this reading.

15 Which balance is sensitive enough to determine if pebble A has a mass larger or smaller than pebble B?

16 The mass reading of pebble B from the Super Balance is 0.020 g. This value is very close, but different than, the mass reading for pebble A on that same balance. Determine which of the three zeros in the mass reading for pebble B is the most significant in terms of determining whether pebble B has a different mass than pebble A, and circle the zero below.

Mass pebble B = 0.020 g

STOP

Model 3 – Types of Zeros

200 g	180 g	140 g	100 g	} **Placeholder Zeros**
0.02 g	0.016 g			
0.020 g	177.0 g	143.0 g		**Significant Zeros** (underlined)

17. Model 3 shows several of the measurements from Model 1 and Model 2. The zeros in those measurements are categorized into two types. List the two types.

18. Consider the term "placeholder" as it is used in the English language. Discuss two examples of this term in your group, and summarize them here.

19. Describe the two types of placeholder zeros shown in Model 3.

20 If you removed a placeholder zero from a number, would the numeric value of the number change?

21 Describe the location of significant zeros in a number relative to the decimal point.

22. If you removed a significant zero from the end of a number, would the numeric value of the number change?

Read This!

Placeholder zeros are very important—they help put the decimal point in the correct spot. However, they are ***not*** significant when it comes to the certainty of a measurement. In other words, placeholder zeros cannot be a certain or estimated digit in a measurement. They may show up in calculations however. For example, if you convert 29.3 m to 29,300 mm, the zeros that you add to the measurement were not read from the measuring instrument.

23 Determine if the zeros in the measurements below are significant or not. If a zero is significant, underline it.

a. 650 m *b.* 42.0 s *c.* 7000 L

d. 3.000 kg *e.* 0.008 mL *f.* 0.00560 cm

24 Here are five rules for determining which digits in a measurement are significant. Match each rule to a set of examples in the table below. The significant digits in each example are underlined.

Rule 1: All non-zero numbers are significant. Set ____

Rule 2: Sandwiched zeros (those that occur between two significant digits) are significant.

Set ____

Rule 3: Zeros that are only placeholders for a decimal are not significant.

Set ____

Rule 4: Zeros at the end of a number that also contains a decimal are significant.

Set ____

Rule 5: Exact numbers (no doubt or uncertainty in the value) may be thought of as having an *infinite* number of significant digits. These include numbers that were counted or are defined values (*i.e.*, conversion factors).

Set ____

Set A	**Set B**	**Set C**
105 cm, 0.402 g, 4003.7 mL, 10.0 s	6300 mL, 400 m, 0.004 g, 0.097 kg	30.40 m, 1.620 s, 0.0400 L
Set D	**Set E**	
589 s, 45 kg, 5.68 g, 0.452 L	1 dozen = 12 1 m = 100 cm 29 students on a bus	

25 Underline all of the significant digits in the following values.

a. 94,000 m *b.* 7200 apples *c.* 0.004380 g

d. 400.0 kg *e.* 80,050 s *f.* 1000 g = 1 kg

Significant Zeros