Significant Zeros

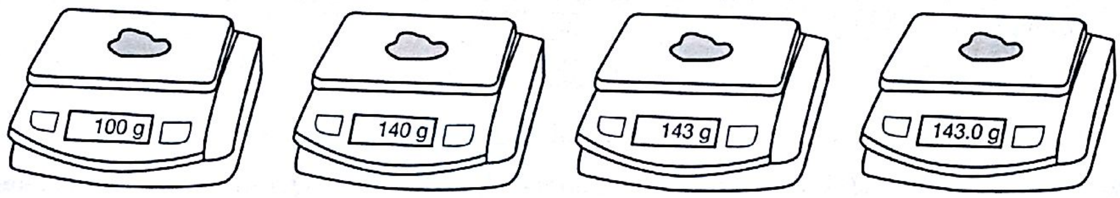
Which zeros are significant in a measurement, and which are simply important?

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.

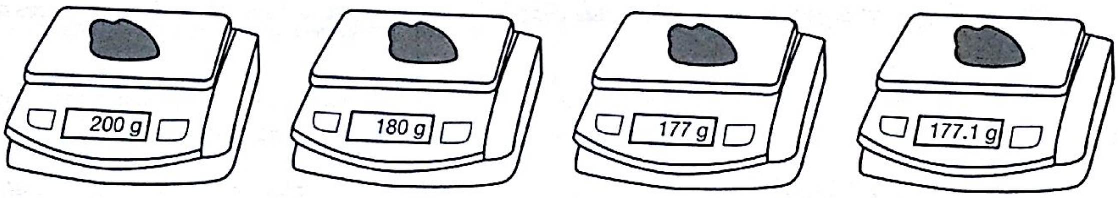
Model 1 – Mass of Rocks

Sample A



Econo-Balance Good Balance Balance Pro Exacto-Balance

Sample B



Econo-Balance Good Balance Balance Pro Exacto-Balance

1. 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

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

The Exacto-Balance is best because…

it gives the most digits.

it measures in smaller increments (0.1 g vs. 1 g).

3. 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.

   Rock C has a mass that is larger than sample A because 200 g is more than 100 g.

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

   It is impossible to tell. The Econo-Balance does not give enough information. Even though the readings for the two rocks are the same, the measurement is rounded so one might be larger than the other.

4. 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.

   It appears that rock B has a greater mass by 0.1 g. However, the last digit in a measurement is uncertain, so an argument could be made that it is impossible to tell which rock has the greater mass.

   b. Explain why the zero in the Exacto-Balance reading provides important information about the mass of rock C, but the zero in the Good Balance reading does not.

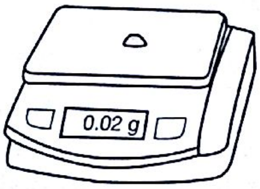
   The zero in the Good Balance reading is neither a certain or uncertain digit. It is past the already rounded number "8" and thus serves as a placeholder. However, the zero in the Exacto-Balance reading is the uncertain digit, so it gives important information.

STOP

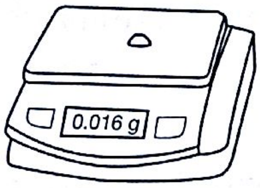
Model 2 – Mass of Pebbles

Pebble A

Balance Pro



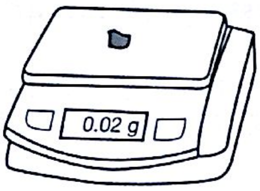
Centi-Balance



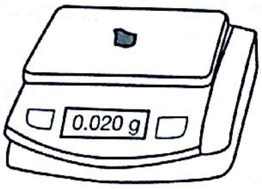
Super Balance

Pebble B

Balance Pro



Centi-Balance



Super Balance

5. 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: *Rounded to the nearest 0.01 g.*

   Super Balance: *Rounded to the nearest 0.001 g.*

6. 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.

   No—their mass is less than 1 gram. The balance is not sensitive enough to give a reading.

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

   The Super Balance is the only balance that shows any difference in mass.

8. 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

Model 3 – Types of Zeros

200 g	180 g	140 g	100 g	Placeholder Zeros
0.02 g	0.016 g			
0.02<u>0</u> g	177.<u>0</u> g	143.<u>0</u> g		**Significant Zeros** (underlined)

9. 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.

   Placeholder zeros.

   Significant zeros.

10. 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.

    Answers may vary.

    Holding someone's place in line.

    Using a book marker to hold your place as you read.

    Placing your coat on a chair to save a seat.

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

    Before the decimal and after the decimal.

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

    Yes. Example: 200 → 2

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

    They are always to the right of the decimal at the end of a number.

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

    No. Example: 177.0 → 177

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.

15. 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

16. 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 D.

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

Set A.

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

Set B.

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

Set C.

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 E.

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	

17. In the measurements below, the significant digits are underlined. Determine the rule(s) that were used to decide which digits were significant, and which were not significant.

a. 0.420 g — Rules 1 and 4
b. 2100 g — Rules 1 and 3
c. 51.0 m — Rules 1 and 4
d. 590 students — Rules 1 and 5
e. 5,200.0 g — Rules 1, 2, and 4
f. 6020 mg — Rules 1, 2, and 3

18. 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

STOP

Extension Questions

Model 4 – Scientific Notation (Significant digits are underlined.)

A. $\underline{3} \times 10^4$ m = $\underline{3}0{,}000$ m
$\underline{3.00} \times 10^4$ m = $\underline{30{,}0}00$ m

B. $\underline{7} \times 10^{-3}$ kg = $0.00\underline{7}$ kg
$\underline{7.00} \times 10^{-3}$ kg = $0.00\underline{700}$ kg

C. $\underline{4.1} \times 10^4$ m = $\underline{41}{,}000$ m
$\underline{4.10} \times 10^4$ m = $\underline{41{,}0}00$ m

D. $\underline{9.42} \times 10^{-3}$ kg = $0.00\underline{942}$ kg
$\underline{9.420} \times 10^{-3}$ kg = $0.00\underline{9420}$ kg

19. The measurements in Model 4 are written in both scientific notation and expanded notation. Copy one example of each below.

Scientific notation: *3.00×10^4 m*

Expanded notation: *30,000 m*

20. Refer to the two measurements in set A of Model 4.

a. Do the two measurements have the same numeric value?

Yes.

b. Were the two measurements made using the same instrument? Explain.

No, the second measurement (3.00×10^4 m) has more significant digits, implying that it was made with a more sensitive instrument.

21. Look at all of the measurements in Model 4. When a number in scientific notation is changed to expanded notation, are any of the added zeros significant? Give two examples to support your answer.

No. $\underline{3.00} \times 10^4$ m = $\underline{30{,}0}00$ m $\quad$ $\underline{7.00} \times 10^{-3}$ kg = $0.00\underline{700}$ kg

22. When a number in scientific notation contains a significant zero, is that zero also significant in the expanded notation? Give two examples to support your answer.

Yes. $\underline{3.00} \times 10^4$ m = $\underline{30{,}0}00$ m $\quad$ $\underline{7.00} \times 10^{-3}$ kg = $0.00\underline{700}$ kg

23. Write each of the measurements below in expanded notation and underline the significant digits.

a. 5.0780×10^6 g = $\underline{5{,}078{,}0}00$ g

b. 4.800×10^{-4} L = $0.000\underline{4800}$ L

c. 0.7200×10^4 mm = $\underline{7{,}200}$ mm

d. 3700×10^{-3} cm = $\underline{3.7}$ cm