

Significant Figures

Using a measuring device correctly: Rulers & Cylinders

When making measurements, the measuring device controls the "exactness" of the number that can be recorded i.e. the number of digits that can be written down.

	Gray bar	Black Bar
Use ruler A and record the length of the gray bar and black bar	_____	_____
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Which ruler must have been used to make the following measurements?

4.23 cm 17 cm 9.3 cm 5.00 cm 2.0 cm

The measuring device determines how many decimal places you can record.

Look at the cylinder closely and determine the value of the smallest line, and then record the measurement one decimal place beyond that value.

Record the amount of liquid in each of the three graduated cylinders at your table:

 10 ml cylinder

 100 ml cylinder

 1000 ml cylinder

Significant Figures

The numbers that are written down using the measuring device to the proper degree of uncertainty are known as significant figures - these are the numbers in a measurement that are known for certain plus the last estimated number.

Remember each measuring device has a particular number of significant figures that can be recorded. We'll call this the "exactness". Whenever you use a measurement that someone else recorded, you must assume that they used the measuring device properly.

So when you look at a measurement, which numbers are sig figs?

- 1 All nonzero digits are SF.
- 2 a. Captive zeros are sig figs (wedged between sig figs).
- b. Leading zeros are NOT sig figs
- c. Trailing zeros are sig figs if there's a decimal.

Alternatively you can combine rules 2b & 2c into this one statement:

Non-wedged zeros are only SF if they are to the right of a decimal **AND** to the right of a nonzero (not necessarily beside)

- 3 Exact numbers are "infinitely" significant:
 - counting numbers
 - defined conversion factors

Why do we care about significant figures?

The reason we need to be able to identify which digits in a measurement are significant is because when we use these numbers in calculations we need to decide how we will round off the answers. We cannot have our computations be any more exact than the measurements that went into the calculation.

Use the 10 ml cylinder to determine the volume of one drop from eye dropper. Since a drop is so tiny, perhaps you would do better making several drops and taking an average.

Now that you know the volume of one drop add one drop to the 1000 ml cylinder and determine the new volume. Since clearly you can not even see that drop that was added, you can see why we need to worry about the significant figures when we calculate using measurements. It is necessary to be concerned with the SF in measurements and not compute answers that are any more accurate than the original measurements allow.

256	large cylinder
+ 0.05	eye dropper

256	(mathematically 256.05, but not valid with the measuring devices.)

The rules for rounding off after calculations:

We will use two separate rules for rounding off:

1. Multiplication/division: The result must be rounded to the same number of significant figures as the measurement with the fewest significant figures.
"How Many"
2. Addition/subtraction: The result must be rounded to the same (smallest, least to the right) decimal place as the measurement with the fewest number of decimal places, (least far to the right)
"Where"

$\begin{array}{r} 12.3 \\ + 456.78 \\ \hline 469.08 \\ 469.1 \end{array}$	<p>"Where"</p> <p>(not 469 if you incorrectly applied the mult/div rule)</p>
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$\begin{array}{r} 12.38 \\ \times 5.6 \\ \hline 69.328 \\ 69 \end{array}$	<p>"How Many"</p> <p>(not 69.3 if you incorrectly applied the mult/div rule)</p>
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Practice:

1. Identify the significant figures in the following measurements:

- | | | |
|--------------------------|------------------------------|---|
| a. 234 m | | <u>234</u> m |
| b. 204 ml | | <u>204</u> ml |
| c. 230 min | <u>230</u> min | not the 0, its to the right of a digit, but not to the right of a decimal |
| d. 230.0 g | | 230.0 g |
| e. 2.9°C | | 2.9°C |
| f. 2.09 kg | | 2.09 kg |
| g. 20.9 mph | | 20.9 mph |
| h. 2.90 cg | | 2.90 cg |
| i. 0.56 cm ³ | <u>0.56</u> cm ³ | not the 0 in front since they are not to the right of a digit |
| j. 0.056 g/ml | <u>0.056</u> g/ml | neither 0's in front since they are not to the right of a digit |
| k. 0.0506 mm | <u>0.0506</u> mm | neither 0's in front since they are not to the right of a digit |
| l. 0.0560 m ² | <u>0.0560</u> m ² | neither 0's in front since they are not to the right of a digit |
| m. 0.05060 mg | <u>0.05060</u> mg | neither 0's in front since they are not to the right of a digit |
| n. 1.056 dm ² | | <u>1.056</u> dm ² |
| o. 1.05060 L | | <u>1.05060</u> L |

2. Round the following computations to 3 significant figures:

- | | |
|----------------------------|--------------------------------|
| a. 163.8 g | 164 g |
| b. 16.065 ml | 16.1 ml |
| c. 1.0694 L | 1.07 L |
| d. 1.10275 cm ² | 1.10 cm ² |
| e. 1.10875°C | 1.11°C |
| f. 9.99840 g/ml | 10.0 g/ml |
| g. 3.465 kg | 3.46 kg or 3.47 kg your choice |

3. Round the answers off to the appropriate number of significant figures and put on the appropriate unit label.

- | | |
|--|---|
| a. 6.4 m * 8.03 m = (51.392) | 51 m ² (2 sf) |
| b. 6.4 g/ml * 8.11 ml = (51.904) | 52 g (2 sf) |
| c. 4.18 J/g°C * 6.527 g * 2.5°C = (68.20715) | 68 J (2 sf) |
| d. 8.307 g / 9.65 ml = (0.860829015) | 0.861 g/ml (3 sf) |
| e. 1.27 m ² / 0.036 m = (35.27777778) | 35 m (2 sf) |
| f. 12.000 g / 8.56 g/ml = (1.401869159) | 1.40 ml (3 sf) |
| g. 6.73 g + 3.2 g = (9.93) | 9.9 (to the 10ths place) |
| h. 3740 m - 96.275 m = (3643.725) | 3640 m (to the 10s place) |
| i. 12.000 g / 8.56 g/ml = (1.401869159) | 1.40 ml (3 sf) |
| j. 38,670 miles / 73.0 hrs = (529.726027) | 5.30 x 10 ² (which is 530, but the zero would not be significant, and you need 3 sf) |

Answers to Ruler question at the top of page one: Which ruler was used? Ruler C, A, B, C, B