

Flipping Physics Lecture Notes: Introduction to Significant Figures with Examples

Significant Figures are a necessary part of any math based science. Significant Figures are the digits in your number that were actually measured plus one estimated digit.

Significant Figures Rules:

- 1) All nonzero digits are significant.
- 2) Zeros between significant digits are significant.
- 3) Zeros to the left of nonzero digits are not significant.
- 4) Zeroes at the end of a number are significant only if they are to the right of the decimal point.

Significant Figures Examples

Number	Significant Figures
70.2	3
0.045	2
70.0	3
4.7	2
100	1
706	3
400.0	4
0.002	1
0.0020	2
0.002047	4
1.0	2
104,020	5
1.20×10^3 (illustrating 1200 with 3 sig figs)	3
2.00×10^{-3} (illustrating 0.002 with 3 sig figs)	3

Flipping Physics Lecture Notes: Rounding and Working with Significant Figures in Physics

Rounding Rules:

- 1) If the number ends in something greater than 5, then you round up.
- 2) If the number ends in something less than 5, then you round down.
- 3) (The Arcane Rounding Rule) If the number ends in a perfect 5 (in other words all or no zeros after the five), you round to the even number.

Addition and Subtraction: Round to the smallest number to the right of the decimal.

Multiplication and Division: Round to the number that has the least number of significant digits from the measured or given values.

Rounding & Significant Figures Examples

Original Number	Number of Significant Figures Wanted	Rounded Number
36.0501	3	36.1
0.01249	2	0.012
26.5	2	26
26.500000000000	2	26
275	2	280
275.000000000000	2	280
$56.1 + 23.22 = 79.32$	Addition Rule	79.3
$1030 \times 5.1 = 5253$	Multiplication Rule	5300

When we do a problem in physics, you end with the least number of Significant Figures from the givens.

Givens: $\Delta x = 10.7$ m (3 sig figs), $v_i = 14$ m/s (2), & $\Delta t = 72.040$ s (5)

- Do your algebra and **Don't Round in the Middle of a Problem!!**

Answer: Has 2 significant digits because the least number was on v_i or 2 sig figs.

You should only round when you give an answer. If part (b) of a problem uses the answer from part (a), you should use the unrounded answer from part (a) to solve for part (b) and then round to the correct number of significant figures.

Flipping Physics Lecture Notes: Introduction to Base Dimensions and Your Friends

Dimensions are your Friend. If you play with them, they will play with you when you need them to.

Base Dimensions are the most basic dimensions in a system of measurement.

Two systems of measurement:

- 1) "Système international d'unités" or the S.I. Units or the Metric System.
- 2) English Units also called Imperial Units

Base Dimensions

	Metric	English
Length	Meter (m)	Foot (ft)
Mass	Kilogram (Kg)	Slug
Time	Seconds (s)	Seconds (s)

Flipping Physics Lecture Notes: Introduction to Conversions in Physics

Dimensions are your Friends: Please remember that the more you play with dimensions the more that they will be your friend and the more that they will help you out when you need them most; on a quiz or final exam.

No Naked Numbers: Always clothe your number answers with dimensions or units. Always. Okay, not really, however, it is a good place to start. Until we get to the coefficient of friction, μ , there will be no naked numbers.

Please don't do magic, it is not math. Just moving a decimal over is magic. You must do conversions.

$$1000mm = 1m \Rightarrow \frac{1000mm}{1000mm} = \frac{1m}{1000mm} \Rightarrow 1 = \frac{1m}{1000mm}$$

(1000 mm = 1 m is an exact conversion and has as many significant digits as you need it to have)

We can multiply any number by one and not change the original number, therefore we can multiply any

number by the conversion factor $\frac{1m}{1000mm}$ because it is the same thing as multiplying by 1.

Example: Convert 11 millimeters to meters.

$$11mm \times \frac{1m}{1000mm} = 0.011m \quad \text{is the same thing as} \quad \frac{11mm}{1000mm} = \boxed{0.011m}$$

Example: Convert 4.2 centimeters to meters. 100 cm = 1 m

$$4.2cm \times \frac{1m}{100cm} = \boxed{0.042m}$$

Example: Convert 17 g to kg. 1 kg = 1000 g

$$17g \times \frac{1kg}{1000g} = \boxed{0.017kg}$$

Please do not write fractions like this: 17 g x 1 kg / 1000 g because it makes it very hard to know what dimensions to cancel.

Example: Convert $14 \frac{m}{s}$ to $\frac{km}{hr}$ $1hr \times \frac{60min}{1hr} \times \frac{60sec}{1min} = 3600sec$

It is useful to have memorized that 1 hour = 3600 seconds, it will come up often in physics.

$$14 \frac{m}{s} \times \frac{1km}{1000m} \times \frac{3600s}{1hr} = 50.4 \frac{km}{hr} \approx \boxed{5.0 \times 10^1 \frac{km}{hr}}$$

The answer needs to have 2 significant digits because the known value of 14 m/s had 2 sig figs.

Example: Convert 12.2 mm² to m². $1m^2 \neq 1000mm^2$, $1m = 1000mm$

$$12.2mm^2 \left(\frac{1m}{1000mm} \right)^2 = 12.2mm^2 \left(\frac{1^2m^2}{1000^2mm^2} \right) = 12.2mm^2 \left(\frac{1m}{1000mm} \right) \left(\frac{1m}{1000mm} \right)$$

$$\Rightarrow 12.2mm^2 = \boxed{0.0000122m^2 = 1.22 \times 10^{-5} m^2}$$

Example: Convert $120 \frac{km}{hr^2}$ to $\frac{m}{s^2}$

$$120 \frac{km}{hr^2} \left(\frac{1000m}{1km} \right) \left(\frac{1hr}{3600s} \right) \left(\frac{1hr}{3600s} \right) = 0.00925925 \frac{m}{s^2} \approx \boxed{0.0093 \frac{m}{s^2} = 9.3 \times 10^{-3} \frac{m}{s^2}}$$

Flipping Physics Lecture Notes: Introduction to Accuracy and Precision

Accuracy is how close your observed (or measured) values are to the accepted value.

Precision is how close your observed (or measured) values are to one another. (Repeatability)

Precision is also the degree of exactness of a measurement, or how many significant digits it has. However, when comparing Accuracy to Precision, this is not the definition we use.

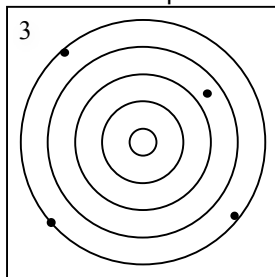
Example Problems question:

Which of the following is true about the Accuracy and Precision represented by this target?

- 1) High Accuracy & High Precision
- 2) Low Accuracy & High Precision
- 3) Low Accuracy & Low Precision
- 4) High Accuracy & Low Precision
- 5) Can't determine Accuracy or Precision
- 6) Can't determine Precision
- 7) Can't determine Accuracy

1st Example: All the arrows are near the bull's eye, so all the measurements would be near the Accepted Value, so it's High Accuracy. All the arrows are near one another, so your measurements are highly repeatable, so High Precision as well. So the answer is #1.

2nd Example: Just like in the previous example all the arrows are close to one another so it is still highly accurate. However, now the measurements aren't near the accepted value, so it is low accuracy. So the answer is #2.



3rd Example: All the arrows are far from one another, so the precision is low. If you take the average of all of the arrows or measurements, then you actually get an average measurement that is close to the accepted value. So the answer is #4, High Accuracy and Low Precision.

4th Example: There is high accuracy because the arrow or measurement is near the bull's eye or accepted value. There is only one measurement so we can't compare it to any of the other measurements so we can't determine Precision. The correct answer is #6.

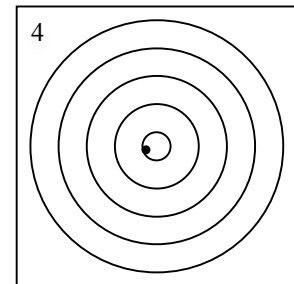
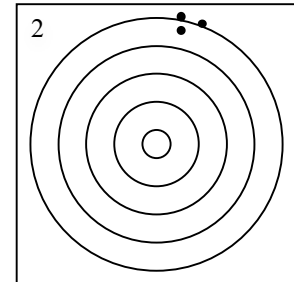
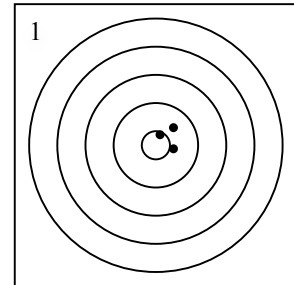
$$E_r = \frac{O - A}{A} \times 100$$

E_r = Relative Error; O = Observed Value; A = Accepted Value.

Relative Error is a measurement of Accuracy.

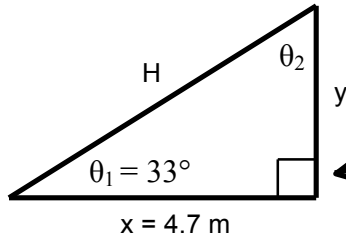
Because the Observed Value and the Accepted Value have the same dimensions, the dimensions cancel out and Relative Error is a percentage.

Enjoy the outtakes. It took a really long time to get these 11 shots to stick to the board and to hit where I needed them.



Flipping Physics Lecture Notes:

A Problem to Review SOH CAH TOA and the Pythagorean Theorem for use in Physics



A *Right Triangle* is a triangle with a right angle or 90° angle. This is a right triangle and the symbol for the right angle is shown here.

In this problem we are trying to find y , H and $\theta_2 = ?$

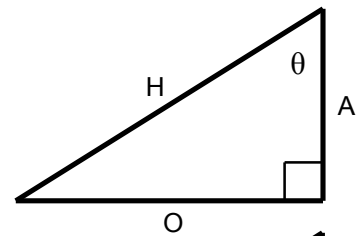
We could use the fact that the interior angles of a triangle add up to 180° , like this:

$$\theta_1 + \theta_2 + 90^\circ = 180^\circ \Rightarrow \theta_1 + \theta_2 = 90^\circ \Rightarrow \theta_2 = 90^\circ - \theta_1 = 90^\circ - 33^\circ = 57^\circ$$

However, because we are trying to review SOH CAH TOA and the Pythagorean Theorem, let's not do that this time. On a quiz or test, you certainly should, however not right now.

SOH means $\sin \theta = \frac{O}{H}$; CAH means $\cos \theta = \frac{A}{H}$ & TOA means $\tan \theta = \frac{O}{A}$

Where O means Opposite, A means Adjacent and H means Hypotenuse. The Hypotenuse is always opposite the 90° angle.

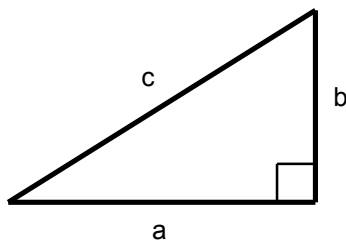
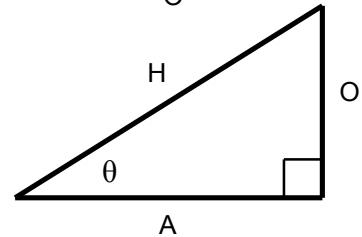


To find the Hypotenuse we can use CAH:

$$\cos \theta = \frac{A}{H} \Rightarrow \cos \theta_1 = \frac{x}{H} \Rightarrow \cos(33) = \frac{4.7}{H} \Rightarrow H \cos(33) = \frac{4.7H}{H}$$

$$\Rightarrow H \cos(33) = 4.7 \Rightarrow \frac{H \cos(33)}{\cos(33)} = \frac{4.7}{\cos(33)} \Rightarrow H = \frac{4.7}{\cos(33)}$$

$$H = 5.6041 \approx \boxed{5.6m}$$



To find y we can use the Pythagorean Theorem:

$$a^2 + b^2 = c^2 \Rightarrow x^2 + y^2 = H^2 \Rightarrow y^2 = H^2 - x^2 \Rightarrow y = \sqrt{H^2 - x^2}$$

$$\Rightarrow y = \sqrt{5.6^2 - 4.7^2} = 3.0447 \approx \boxed{3.0m}$$

To find θ_2 we can use TOA:

$$\tan \theta = \frac{O}{A} \Rightarrow \tan \theta_2 = \frac{x}{y} = \frac{4.7}{3.0522} \Rightarrow \tan^{-1}(\tan \theta_2) = \tan^{-1}\left(\frac{4.7}{3.0522}\right)$$

$$\theta_2 = \tan^{-1}\left(\frac{4.7}{3.0522}\right) = \boxed{57^\circ}$$

Remember, SOH CAH TOA and the Pythagorean Theorem only work on Right Triangles.