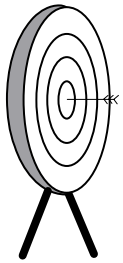
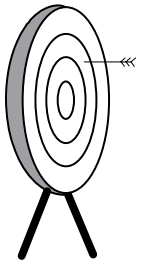
Accuracy and Precision

Accuracy is all about how close to what you're aiming for you get. For instance, in archery, you're trying to get as close to a bullseye as possible (an arrow hitting the circular target exactly in the centre).

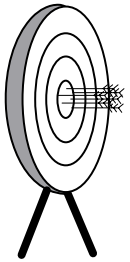


A very accurate shot

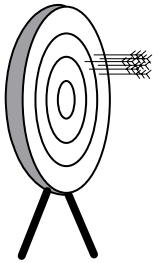


A not so accurate shot

Precision on the other hand is all about how close *repeated* shots are to each other. Precision has nothing to do however with how close you are to your desired goal.



Precision *and* accuracy



Precision but bad accuracy

Precision in Numbers

300 m - since two zeroes have been written down in the '10's and '1's part of the number, I would read this number as being 300 metres with a precision of 1 metre. If I wanted to tell the reader the measurement was 300 metres with a precision of *100 metres*, I would write:

$$3\times10^2\,m$$

Errors and Measurement

Error

Whenever you measure something, you can't measure it exactly, there's always some amount of *error* in your measurement. The error is just the difference between what you measure and what it should be exactly:

$$\text{Measurement error} = \text{measured value} - \text{correct value}$$

So say I measured something to be 299.8 metres long, and it was actually 300 metres long:

$$\text{Error} = 299.8\,\text{m} - 300\,\text{m}$$

$$\text{Error} = -0.2\,\text{m}$$

Absolute Error

The absolute error is just the absolute value of the error. So in the last calculation, the error was *negative* 0.2 metres. The absolute error is just the positive version of this:

$$\text{Absolute Error} = \left|-0.2\,\text{m}\right|$$

$$\text{Absolute Error} = 0.2\,\text{m}$$

The two vertical lines either side of the '0.2 m' mean 'take the absolute of'.

Greatest possible error

The largest error you can make doing a measurement is exactly one half of the precision of that measurement.

$$\text{Greatest Possible Error} = \frac{1}{2}\text{ of the precision}$$

For 300 metres to a precision of 1 metre:

$$\text{Value} = 300\,\text{m} \pm 0.5\,\text{m}$$

Relative Error

The relative error gives you an idea of how large the error is, given how big the thing you're measuring is. To calculate it divide the error you have by the true value of the thing you're measuring.

$$\text{Relative error} = \frac{\text{Error}}{\text{True value}}$$

Percentage Error

$$\text{Percentage error} = \text{Relative error} \times \frac{100}{1}\%$$

Adding and subtracting numbers with errors

Just *add* the errors (you add the errors *regardless* of whether the numbers are being added or subtracted):

$$(4.0\,\text{m} \pm 0.01\,\text{m}) + (1.00\,\text{m} \pm 0.005\,\text{m})$$

$$= 5\,\text{m} \pm 0.015\,\text{m}$$

Multiplication or division by an exact number

Just multiply/divide both the number *and* the error by the exact number. For instance:

$$\Rightarrow (4 \pm 0.5) \times 5$$

$$= 20 \pm 2.5$$

Multiplication of numbers with small errors

$$\text{Error} \approx \text{first number} \times \text{error in second number} + \text{second number} \times \text{error in first number}$$

$$(4 \pm 0.05) \times (7 \pm 0.1) = 28 \pm 0.75$$

Division of numbers with small errors

The **relative** error in the result of a division is the **relative** error in the numerator plus the **relative** error in the denominator.