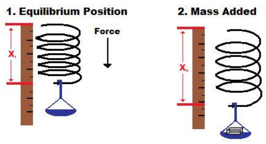
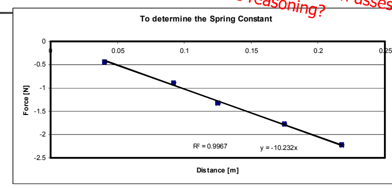
Maths Support on blackboard



Displacement [m]	Force [N]	Error on Displacement	Error on Force
0.0405	-0.4454	0.001	0.01
0.092	-0.8898	0.001	0.01
0.125	-1.3342	0.001	0.01
0.175	-1.7756	0.001	0.01
0.218	-2.2269	0.001	0.01

Theme report

This student critiques these measurements to be very accurate (can't even see the error Bars). Do you think an assessor will agree with the reasoning?



•Template draws a graph for you, fits to an equation, puts up your error bars, gives you R^2 (a widely used measure of how good the fit is)
•**Play with the report template now**
•**Look at the questions you need to answer before you start a Theme**

Systems of Measurements, SI

- SI (standard international) system

  We use this mainly
  - Length is measured in meters (m)
  - Time is measured in seconds (s)
  - Mass is measured in kilograms (kg)

FYI, US Customary system

- US Customary
  - Length is measured in feet
  - Time is measured in seconds
  - Mass is measured in slugs

Prefixes

- Prefixes correspond to powers of 10
- Each prefix has a specific name
- Each prefix has a specific abbreviation

Prefixes, cont.

- The prefixes can be used with any base units
- They are multipliers of the base unit
- Examples:
  - 1 mm = 10^{-3} m
  - 1 mg = 10^{-3} g

TABLE 1.4
Some Prefixes for Powers of Ten

Power	Prefix	Abbreviation
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z
10^{24}	yotta	Y

Units of an EQUATION must EQUATE

1) Given the equation: v = a / t
   Check the units on each side. Can it be valid?
2) Using: F = m a (Newton II)
   The unit of force is N. What else is the N equivalent to in SI units?
3) Using: E = ½ m v^2
   The unit of energy is J. What else is the J equivalent to in SI units?

Units conversion

- Always include units for every quantity, you can carry the units through the entire calculation
- Multiply original value by a ratio equal to 1
  - The ratio is called a **conversion factor**
- Example $15.0\,\text{in} = ?\,\text{cm}$

$$15.0\,\text{in}\left(\frac{2.54\,\text{cm}}{1\,\text{in}}\right) = 38.1\,\text{cm}$$

Conversion practice problem

How many hours is 2300 s?

$$1)\ \ 2300.0s = 2300.0s\left(\frac{60.60s}{1h}\right) = ?$$

$$2)\ \ 2300.0s = 2300.0s\left(\frac{1h}{60.60s}\right) = ?$$

Answer: 0.6388888888888888889 h WRONG

Right answers: 0.63889 or say 0.64 h to 2 S.F.

Conversion practice problem

How much is 11 stone in kg?

1 stone is 14 lb

1 kg is 2.2 lb

$$11st = 11st\left(\frac{14lb/st}{2.2lb/kg}\right)$$

$$11st = 11st\left(\frac{14kg}{2.2st}\right)$$

$$11st = 11\left(\frac{14}{2.2}\right)kg$$

$$11st = 11\left(\frac{14}{2.2}\right)kg = 70.0kg$$ NO

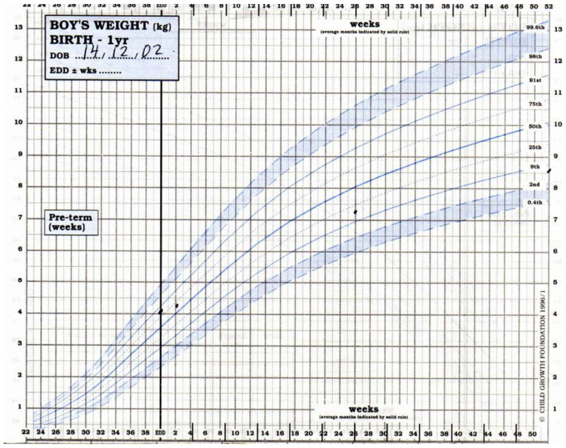
Right answer: 11st = 70 kg accurate to 2 S.F.

Order of Magnitude

- Approximation based on a number of assumptions
  - May need to modify assumptions if more precise results are needed
- Order of magnitude is the power of 10 that applies
- In order of magnitude calculations, the results are reliable to within about a factor of 10

Uncertainty in Measurements

- There is uncertainty in every measurement, this uncertainty carries over through the calculations
  - Need a technique to account for this uncertainty
  - Need to give value + units + degree of certainty



Error bars

- Error bars typically represent 1 SD (standard deviation)
- For genuinely random statistics, there is a 2/3 probability of a measurement being delivered within this error bar
- In this module, estimate error bars and you be clear about what your error bars represent (how they are derived).
- For example, if you took more time to take more measurements, would expect that most of your measurements would fall within an error bar you give?
- If you manage to repeat measurements (in different ways?), do you represent the spread of results with your error bar?

Significant Figures

- A significant figure is one that is reliably known
- Zeros may or may not be significant
  - Those used to position the decimal point are not significant
  - To remove ambiguity, use scientific notation
- In a measurement, the significant figures include the first estimated digit

Significant Figures, examples

- 0.0075 m has 2 significant figures
  - The leading zeroes are placeholders only
  - Can write in scientific notation to show more clearly: 7.5×10^{-3} m for 2 significant figures
- 10.0 m has 3 significant figures
  - The decimal point gives information about the reliability of the measurement
- 1500 m is ambiguous
  - Use 1.5×10^3 m for 2 significant figures
  - Use 1.50×10^3 m for 3 significant figures
  - Use 1.500×10^3 m for 4 significant figures

Multiplying or Dividing Rule: consider Significant Figures

- When multiplying or dividing, the number of significant figures in the final answer is the same as the number of significant figures in the quantity having the lowest number of significant figures.
- Example: 25.57 m x 2.45 m = 62.6 m^2
  - The 2.45 m limits your result to 3 significant figures

Adding or Subtracting Rule: consider Decimal Places

- For Adding or subtracting, the number of decimal places in the result should equal the smallest number of decimal places in any term in the sum.
- Example: 135 cm + 3.25 cm = 138 cm
- Example: 20.3 cm – 11.2 cm = 9.1 cm
- Example: 20.3 cm – 11.21 cm = 9.1 cm
- Example: 20.3 cm – 11.29 cm = 9.0 cm

Rounding

- Last retained digit is increased by 1 if the last digit dropped is above 5
- Last retained digit remains as it is if the last digit dropped is less than 5
- If the last digit dropped is equal to 5, the retained should be rounded up or, rounded as requested
- Save rounding until the final result. This will help eliminate accumulation of errors.

Summary

- The rule for addition and subtraction are different than the rule for multiplication and division
- For adding and subtracting, the ***number of decimal places*** is the important consideration ('**AD**ding')
- For multiplying and dividing, the ***number of significant figures*** is the important consideration (**'MS'**)