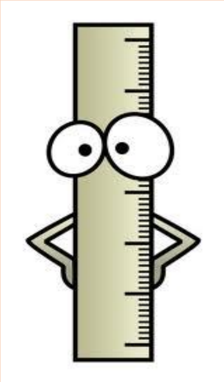
Tuesday, November 15, 2022

Physics - session 1



Learning Objectives:

- Prefixes and units
- Rearranging equations
- Uncertainties
- Graphical analysis
- Resolving and combining vectors

Is your Physics brain working?

- Can you explain the difference between a unit and a quantity?
- Do you know the seven base SI units?
- What is a derived unit? Can you give an example of one?
- What would 1.72nm x 2.672Mm x 5.29fm be? What about to 2 sig figs?

2.4×10^{-17}m

Definition:

A physical quantity is a property of an object which can be measured.

A unit is a particular amount of some quantity used as a reference point for measurements of that quantity.

For example 27m is an amount of the quantity distance

Tip:

Don’t use units when you mean the quantity.

e.g. the student used an ammeter to measure the amps in the circuit – WRONG!

Read:

There are 7 different base units whose definitions are based on specific physical measurements that can be reproduced accurately. All other derived units can be expressed in terms of these base units.

Base quantity	Base unit	Unit symbol
Time	Second	s
Length	Metre	m
Mass	Kilogram	kg
Temperature	Kelvin	K
Electric current	Ampere	A
Amount of substance	Mole	mol

Question:

What are the base units of momentum?

A bit harder – what about the newton?

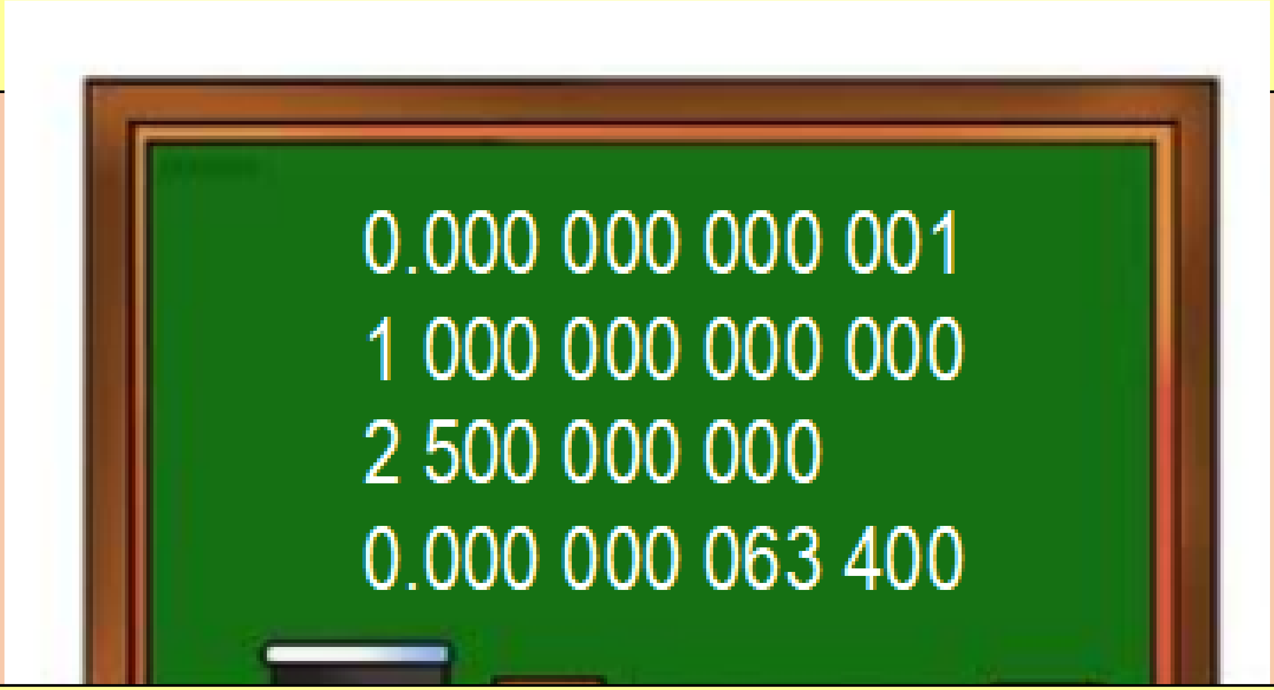
Momentum = $kgms^{-1}$

Density = kgm^{-3}

Newton = $kgms^{-2}$

Joule = $kgm^{2}s^{-2}$

Can you say the following numbers?
How do we simplify them?



Prefixes are used with the base units to make very large and very small numbers more manageable

30 seconds: Can you write out all the prefixes we use in Physics? E.g. milli = 1×10^{-3}

In Physics we use engineering standard form. This is NOT the same as in maths (which uses scientific notation)… it's better ☺ So the number does not need to be between 1.0 and 10.0; but the prefix will be one of the following. Again – because we work in the real world – we usually state answers to **2 sig figs**

Have you ever used the ENG button?

Try 3.56 ÷ 25,632

Then press ENG

And again..

Try SHIFT ENG

Prefix	Symbol	Magnitude
femto	f	X 10^{-15}
pico	p	x 10^{-12}
nano	n	x 10^{-9}
micro	µ	x 10^{-6}
milli	m	x 10^{-3}
centi	c	x 10^{-2}
kilo	k	x 10^{3}
mega	M	x 10^{6}
giga	G	x 10^{9}
tera	T	x 10^{12}

Tip:

When completing calculations, always convert units before you start.

1Gm = 1×10^{9} m

1ps = 1×10^{-12} s

Challenge what about $1mm^3$?

1mm = 1×10^{-3} m

So $1mm^2 = 1 \times 10^{-6}$ m

And $1mm^3 = 1 \times 10^{-9}$ m

Practice:

5 minutes

Complete the questions on SI and derived units

Rearranging Equations:

This is a simple skill which you need to be TOTALLY confident about doing.

Tip:

List out your quantities and check units

Substitute all the values in first

Simplify then rearrange

Example:

Example on the Whiteboard

Be as clear as possible with your working out. Use the space and keep it neat.

Practice: 10 minutes

Complete the questions to practice rearranging equations

Uncertainties:

In Physics we are dealing in the real world (unlike the world of maths). So we acknowledge that all our measurements are subject to a level of uncertainty and we need to quantify this uncertainty.

Before we start: can you define accuracy, precision and resolution?

Definitions:

Precision: relates to how close together repeat values are. The smaller the spread or range, the higher the precision.

Accuracy: How close a measurement or calculated value is to the true value.

Resolution: The resolution of a measuring instrument is the smallest change in a quantity that gives a change in the reading that can be seen.

Absolute Uncertainty:

The absolute uncertainty of a measurement shows how large the uncertainty actually is.

It has the same units as the quantity being measured.

When taking single readings, the absolute uncertainty is usually given as **the smallest division on the measuring instrument used**. (usually shown as half the division – e.g. $1^{o}C$ shown as $\pm$ $0.5^{o}C$)

Thermometer

Reading is between 23 and 24.

We would likely read this 23, but the red line could be as high up as 23.5 or as low down as 22.5 and rounding to the nearest whole number would still read as 23.

This gives our reading an uncertainty of ±0.5 ^{o}C

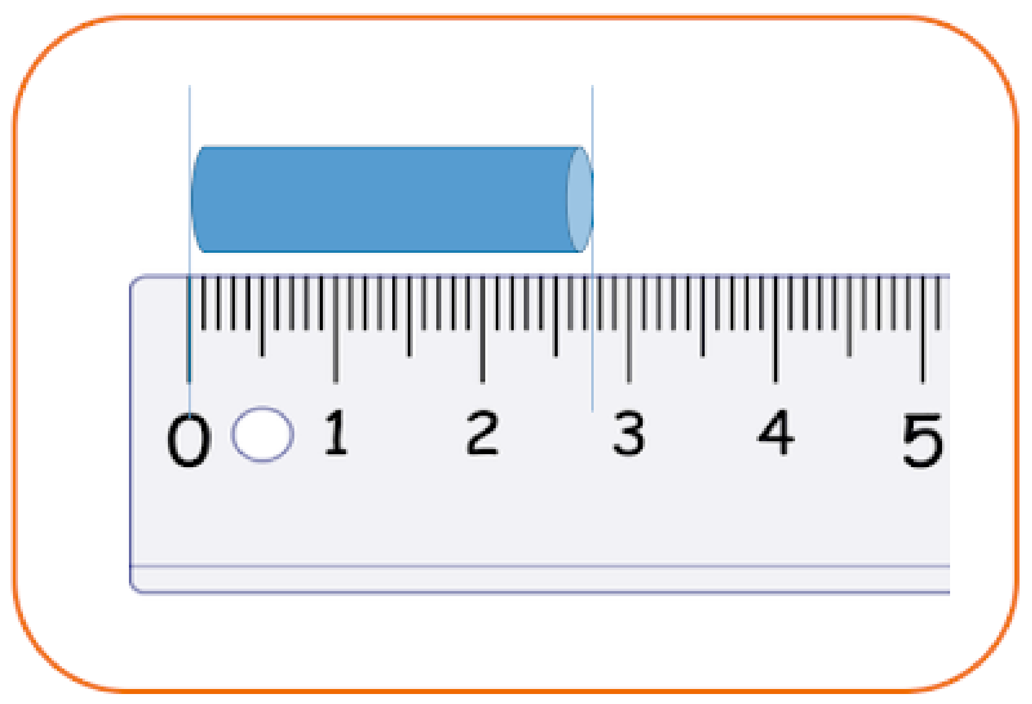
Final reading = 23^{o}C ±0.5 ^{o}C

Ruler

We would likely read this 2.7cm, but the end could be as high up as 2.75 as low down as 2.65 and we would still read to 2.7cm. So there is an uncertainty of ±0.5mm

BUT – there is also an uncertainty at the zero end, and this will also be ±0.5mm

So the final reading = 2.7mm ±1mm



What are the **uncertainties** for these different measuring instruments?
The **resolution** is given.

Absolute Uncertainty:

Meter ruler (1mm)	±1mm
Ammeter (1dp)	±0.05A
Scales (1dp)	±0.05g
Protractor	$\pm 0.5^{o}$
Vernier Calliper (0.1mm)	±0.05mm

Absolute Uncertainty:

When we add or subtract quantities, we need to combine the absolute uncertainties. They are always **added** together.

e.g. we measure the perimeter of the room.

The four walls measure 8m ±0.01m, 5m ±0.01m, 8.3m ±0.01m and 4.9m ±0.01m.

What is the perimeter, including the uncertainty?

Perimeter = 26.2 ± 0.04m

Percentage Uncertainty:

Percentage uncertainty is the absolute uncertainty divided by the measured value expressed as a percentage.

% uncertainties should be expressed to 1 significant figure only.

$$\% \text{ Uncertainty} = \frac{\text{uncertainty}}{\text{measured value}} \times 100\%$$

Percentage Uncertainty of a single value:

What is the percentage uncertainty in a length of 76mm measured with a meter ruler that has a millimeter scale?

$$\% \text{ Uncertainty} = \frac{\text{uncertainty}}{\text{measured value}} \times 100\%$$

Absolute uncertainty = ±1mm

% uncertainty = 1/76 x 100%

= ±1.3%

Tip: If we want to reduce the % uncertainty in a reading, we need to make the measured value larger. The absolute uncertainty remains the same, but the % uncertainty will reduce.

Percentage Uncertainty of a range of values:

- Find and record the mean of the values
- Find the range of the readings
- Halve the range to find the absolute uncertainty
- Divide the uncertainty by the mean and multiply by 100%

$$\% \text{ Uncertainty} = \frac{\text{(half range)}}{\text{mean value}} \times 100\%$$

Reading 1/V	Reading 2/V	Reading 3/V	Reading 4/V	Mean value/V
3.89	3.88	3.86	3.90	3.88

Range = 3.90 – 3.86 = 0.04
Absolute uncertainty = ± 0.02
% uncertainty = ± 0.5%

Combining % Uncertainties:

Just like absolute uncertainties, % uncertainties always **add up** when quantities are combined.

y = ab

% uncertainty in y = % uncertainty in a + % uncertainty in b

y = a/b

% uncertainty in y = % uncertainty in a + % uncertainty in b

y = a^2

% uncertainty in y = 2 x % uncertainty in a

y = a^n

% uncertainty in y = n x % uncertainty in a

Not as confusing as it looks – uncertainties just always ADD UP.

Combining % Uncertainties:

A compound variable is calculated using the formula $y = \frac{ab}{c^3}$

What is the % uncertainty in y if the % uncertainty in a is 3%, b is 6% and c is 2%

% uncertainty = 3% + 6% + 3(2%)
= **15%**

Check your Data booklet – it contains lots of useful formulae

Combining % Uncertainties:

The diameter of a solid sphere is measured with vernier calipers to be 4.73 ± 0.01cm and its mass is measured to be 429.20 ± 0.01g.

a) calculate the density of the sphere in gcm^{-3}

b) calculate the % uncertainty in the density

Density = mass/volume

Volume = $4/3\pi r^3 = 4/3 \times \pi \times (2.365)^3$

$= 55.41cm^3$

Density = 429.20/ 55.41 = **7.7 gcm^{-3}**

% uncertainty = % uncertainty in mass + % uncertainty in volume

= 0.01/429.2 x 100% + 3(0.01/4.73) x 100% = 0.002 + 0.6 = 0.602% = **0.6%**

Graphical Analysis:

Nearly every Physics investigation will include drawing a graph of our results. We can use the graph to calculate the uncertainty in our results. Often we will use the gradient of the graph to calculate a value.

Error Bars:

Error bars are a visual representation of the uncertainty associated with each piece of data.

Error Bars:

1. Plot the mean data value.
2. Calculate the range of the data, ignoring any anomalies.
3. Add error bars with lengths equal to half the range on either side of the data point.

Drawing a Line of Best Fit:

1. Check if your data follow an equation. This will help decide if the line should be straight or curved.
2. The line of best fit should fall within error bars if drawn.
3. A good rule of thumb is to make sure that there are as many points on one side of the line as the other.
4. Lines of best fit should be continuous and drawn with a thin pencil that does not obscure the points below and does not add uncertainty to the measurement of gradient of the line.
5. Not all lines of best fit go through the origin.

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Exam Tip: Mark schemes will expect you to be accurate to within ± ½ a square

Gradient:

1. When finding the gradient of a line of best fit, show your working by drawing a triangle on the line.
2. The hypotenuse of the triangle should be at least half as big as the line of best fit.

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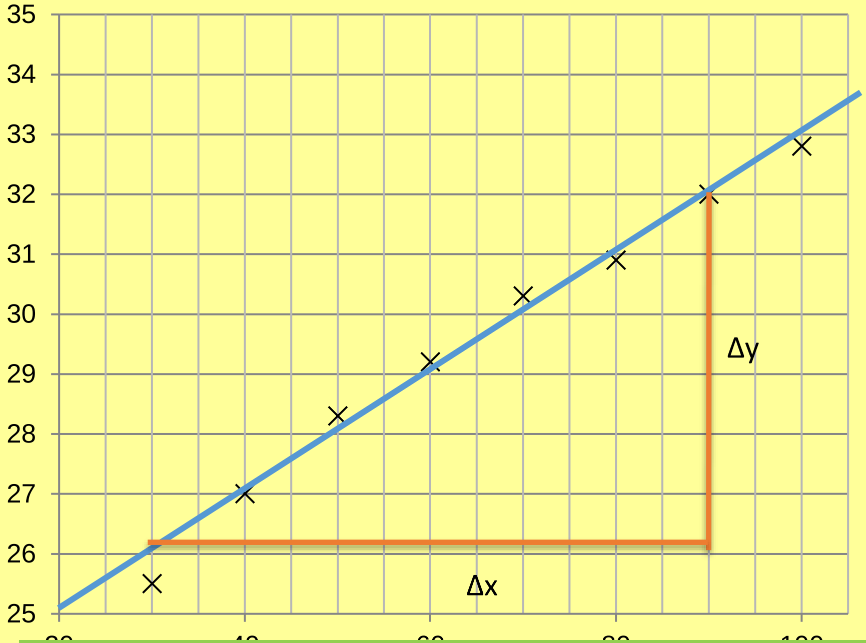


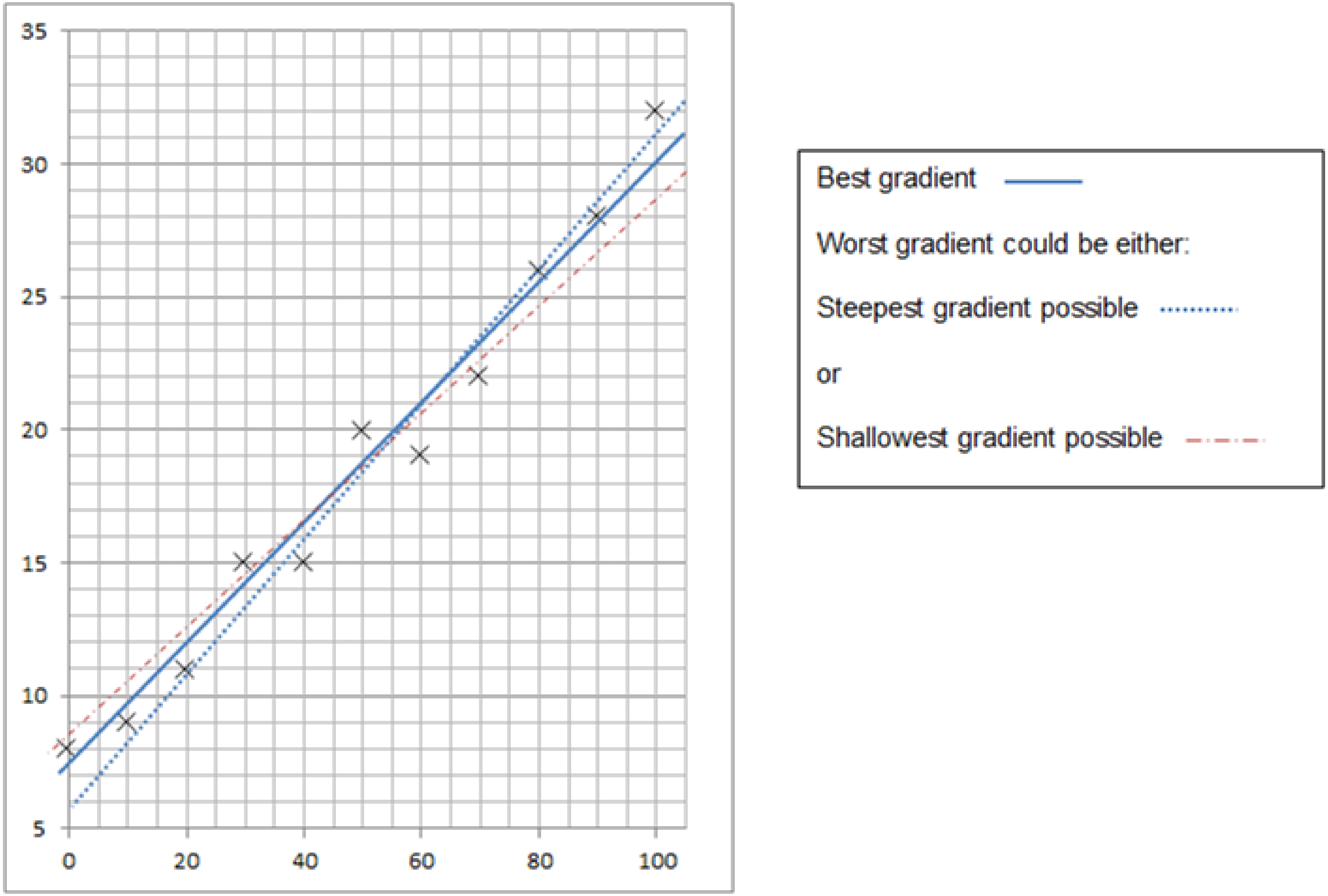
Exam Tip: Markschemes expect you to show clearly on the graph how you calculated the gradient.

Uncertainties from gradients

To find the uncertainty in a gradient, you will need to draw 2 or 3 lines of best fit.

1) Calculate the gradient from the “best” line of best fit.
2) Calculate the gradient from the steepest line of best fit.
3) OR Calculate the gradient from the shallowest line of best fit.
4) Calculate the percentage uncertainty from:

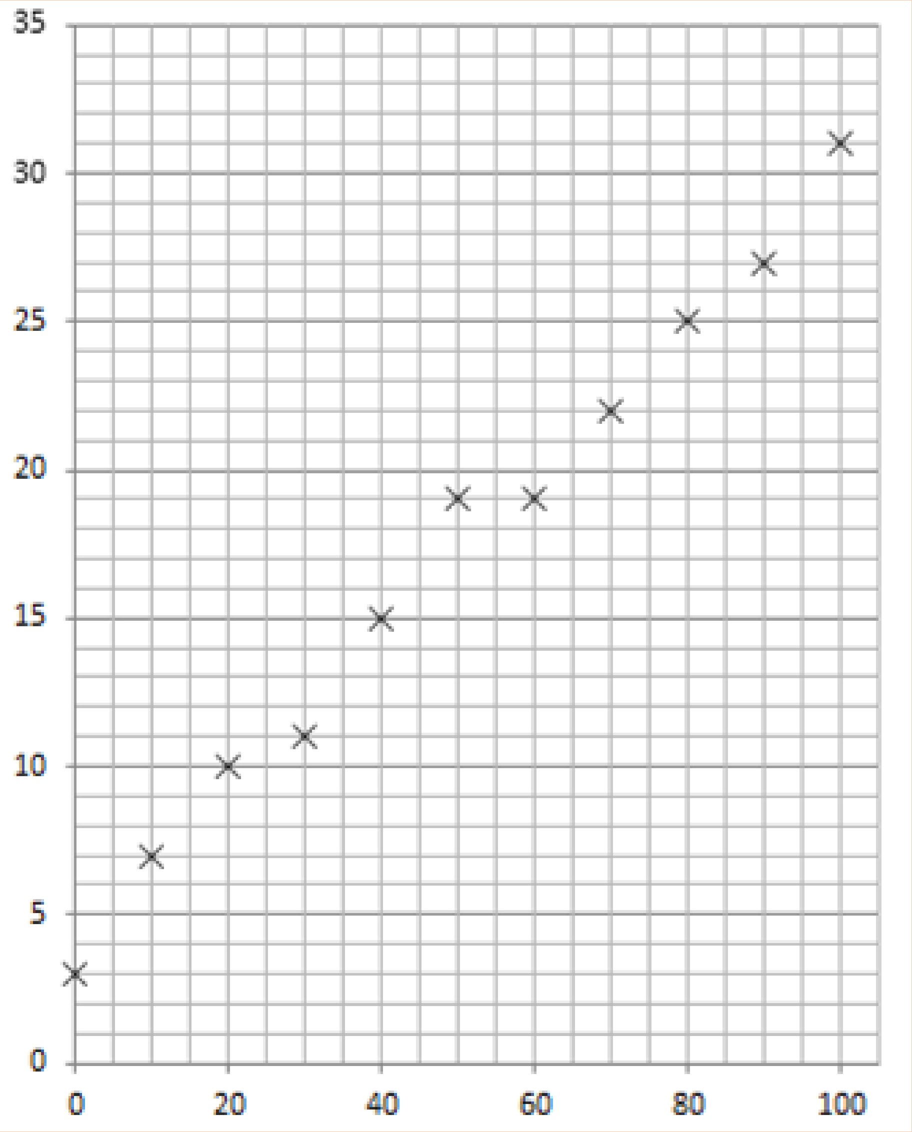
$$\%u = \frac{\text{(best gradient-worst gradient)}}{\text{best gradient}} \times 100\%$$



35
30
25
20
15
10
5
0
20
40
60
80
100
Best gradient
Worst gradient could be either:
Steepest gradient possible
or
Shallowest gradient possible

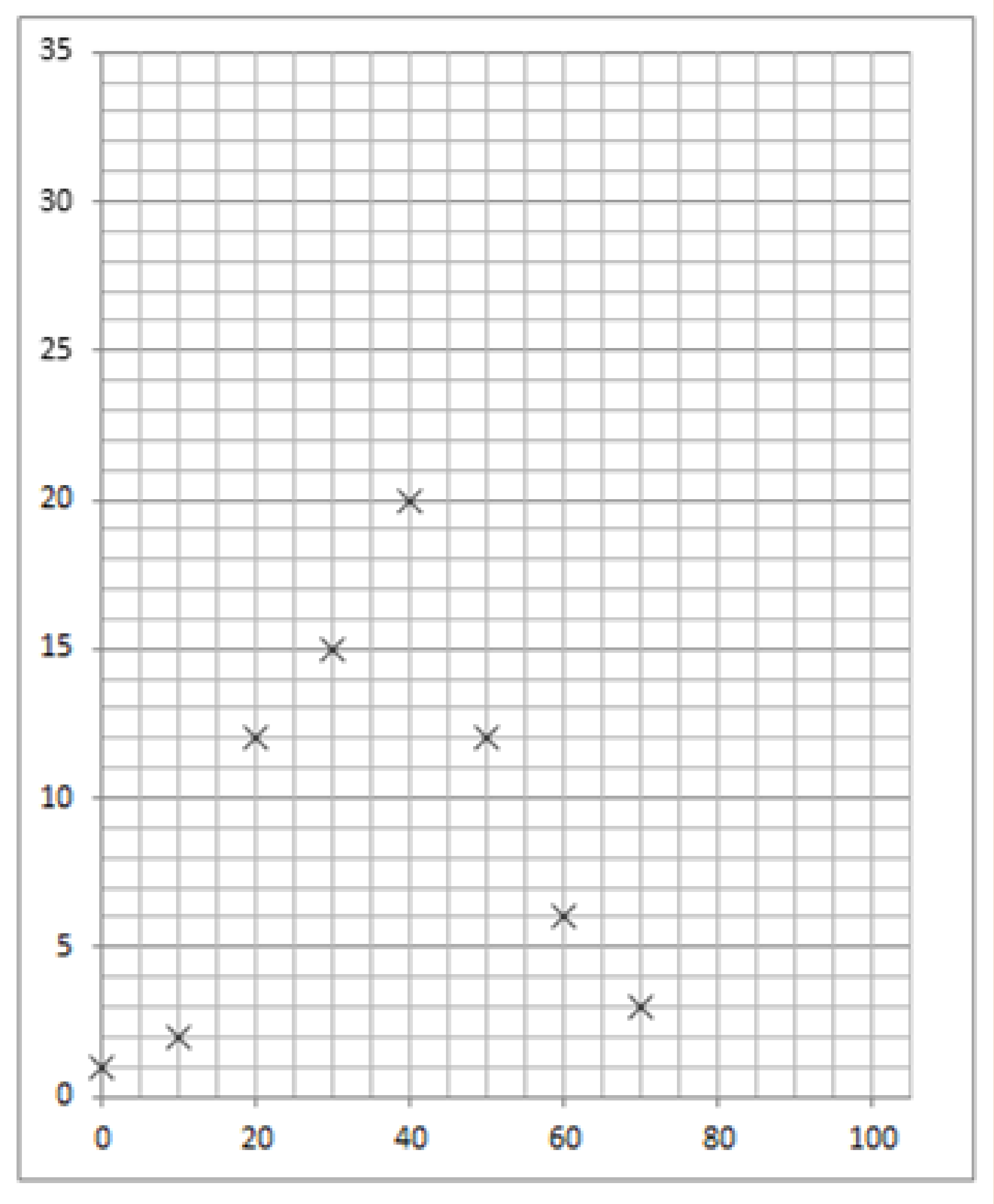
Is this graph well drawn or not?

Scales are good but are not labelled.



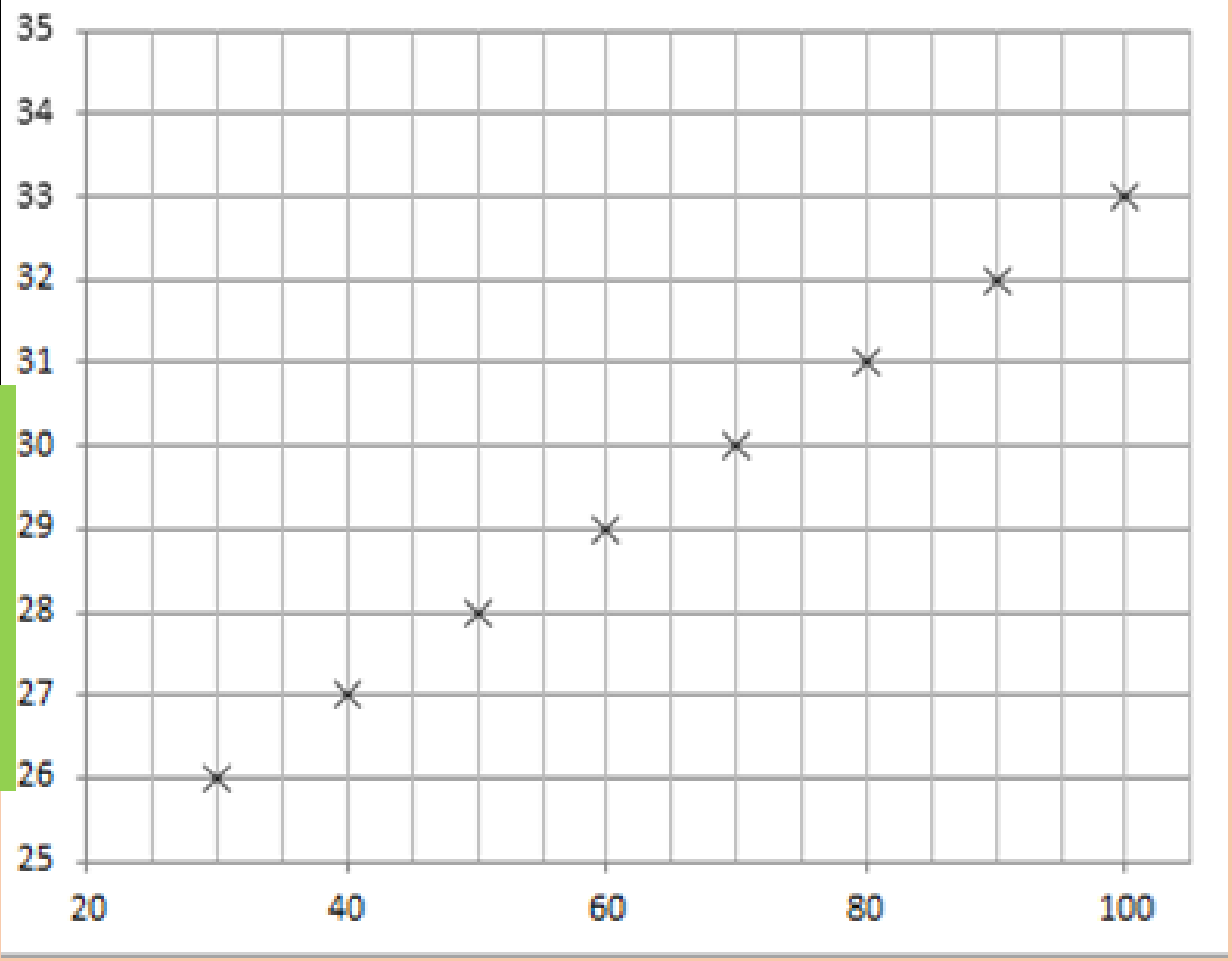
Is this graph well drawn or not?

Not labelled.
Just about taking half the page, but scales would be better if it was spread our more.



What difficulty might there be with using this graph?

Won’t know what the y-intercept is, if we need to work out the equation of the graph.



In practical questions, we will often be asked to plot a graph of the data and then use the gradient of the graph to calculate a value.

We need to use **y = mx + c**
And compare this to the equation used for our graph.

We can then identify what the gradient of the graph is showing us.

For example a graph of v^2 against s for an object being dropped from rest

What does the gradient show?

Hint: From SUVAT
$v^2 = u^2 + 2as$

Gradient = 2 x a

Isaac Physics:

If you haven't already used this website – I highly recommend it!

Go to www.isaacphysics.com
Create an account
Go to Learn - A-level Resources - Question Finder
Then choose Physics and Skills

10 minutes to try any of the Skills questions

Hint: Isaac Physics is very particular about the number of significant figures. Always read the question carefully.

Definitions:

Scalar – a quantity with magnitude only

Vector – a quantity with both magnitude and direction

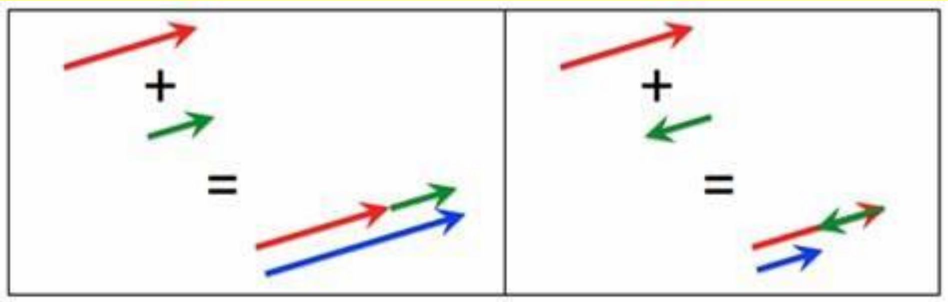
Examples:

Vectors – acceleration; force; weight; velocity; momentum; displacement

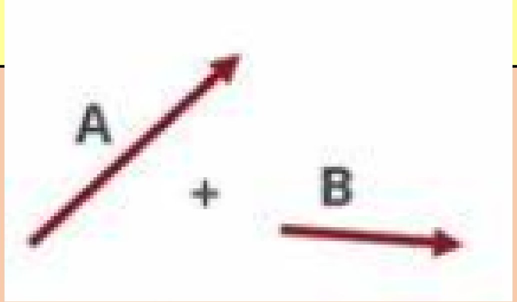
Scalars – energy; mass; temperature; speed; distance

Adding Vectors

If the two vectors are parallel – then it is simply a case of addition or subtraction.



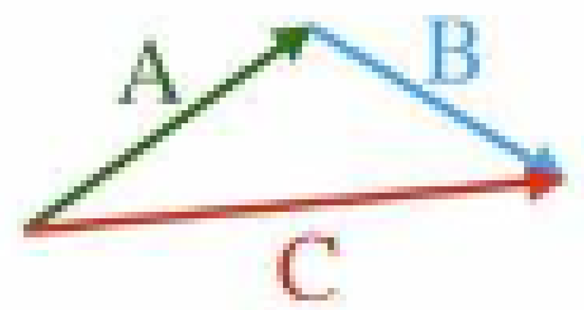
But if the two vectors are at an angle to each other, then we can't just add or subtract.



Adding Vectors which are not parallel

Draw the vectors **Tip to Tail (following on)**

The sum of these vectors (the resultant) is the line which joins the start point to the end point.



$$\vec{A} + \vec{B} = \vec{C}$$

Important: the Resultant is not a 3rd vector – it replaces the first two

Question:

Two vectors of magnitude 7N and 5N are combined.

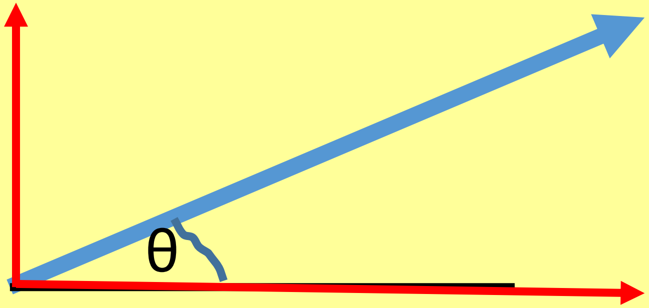
What are the maximum and minimum resultant forces?

Maximum – when they both act in the same direction = 12N

Minimum – when they act in opposite directions = 2N

Question?

What do we mean by resolving a vector?
Why is it so hugely important in Physics?



It is vital that you are confident resolving vectors. If not – then most of the mechanics topic becomes very difficult!

Resolving Vectors

When a vector is at an angle to the surface, we can resolve it into two perpendicular components.

These two components have the same effect as the original vector.

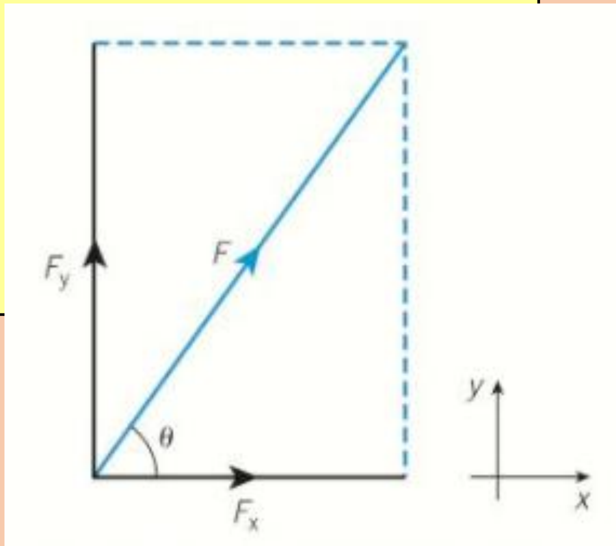
So we can replace the original vector with these two separate vectors.

IMPORTANT

There are **not** three vectors.

Either just F

OR F_x and F_y



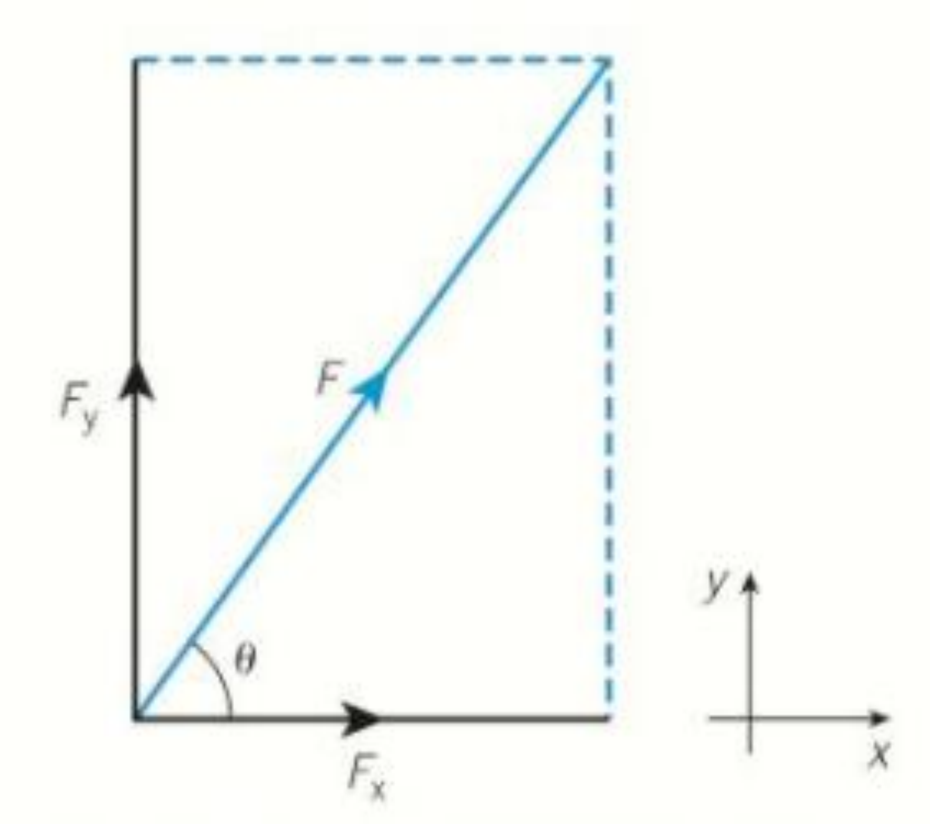
Resolving Vectors

If we resolve a force F into the x and y directions, the two components of the force are equal to:

$F_x = F \cos\theta$

$F_y = F \sin\theta$

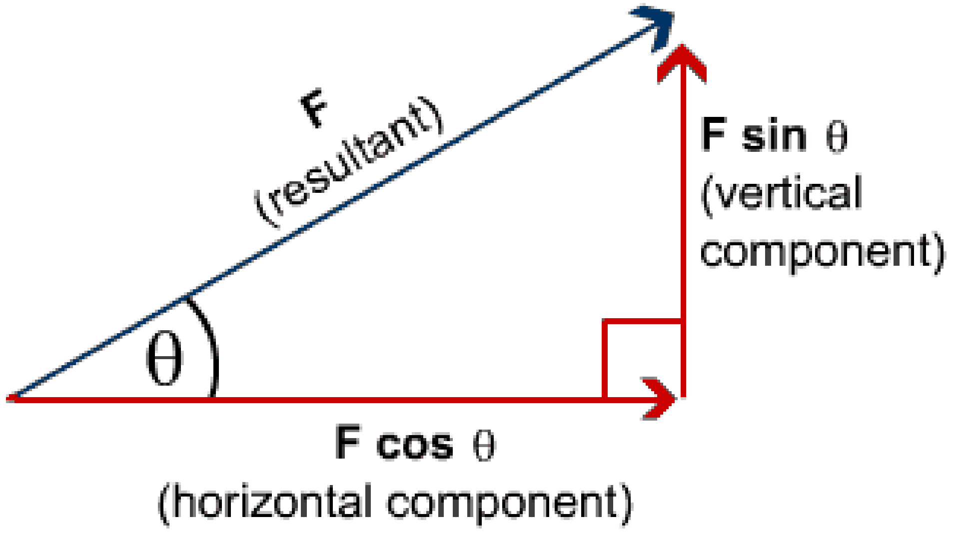
Why?



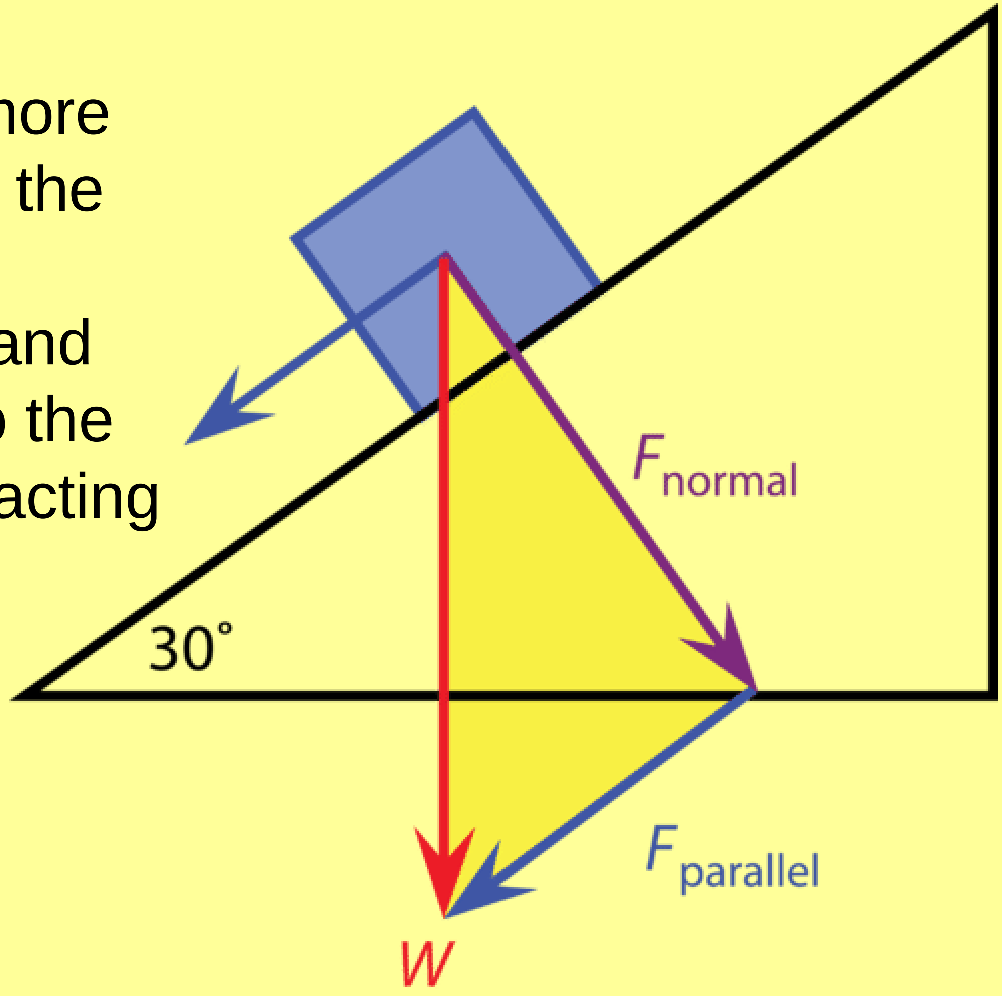
Remember this!!
Think SOH CAH TOA

The component which is **ADJACENT** to the vector is **Fcos θ** (CAH)

The component which is **OPPOSITE** the vector is **Fsin θ** (SOH)



Sometimes it is more helpful to resolve the vectors (usually forces), **parallel** and **perpendicular** to the surface they are acting on



Practice Questions:

Resolving vectors

You have five minutes to complete as many of the questions as possible

Learning Objectives:

- Prefixes and units
- Rearranging equations
- Uncertainties
- Graphical analysis
- Resolving and combining vectors

Summary:

- Always convert any prefixes before doing your calculations
- Substitute in values before you rearrange equations
- Remember that a ruler has uncertainty at both ends
- Uncertainties always add up
- Draw your graphs as large as possible
- Rewrite equations in the form y = mx + c to help determine the gradient of a graph