PiXL partners in excellence

PiXL Science

PiXL6 Gateway

Essential Prior Knowledge for A Level Physics

A Level Physics builds on your GCSE knowledge.

Everyone finds the A Level Physics course difficult, but it is incredibly rewarding so stick at it!

This lesson summarises some of the key concepts from GCSE physics which will help form the foundation of your study of the advanced material in A-Level.

Essential Forces and Motion

Resultant Forces

If there is a resultant force on a object it will accelerate.

An acceleration is the rate change in velocity (remember velocity is a vector).

$$a = (v-u) / t$$

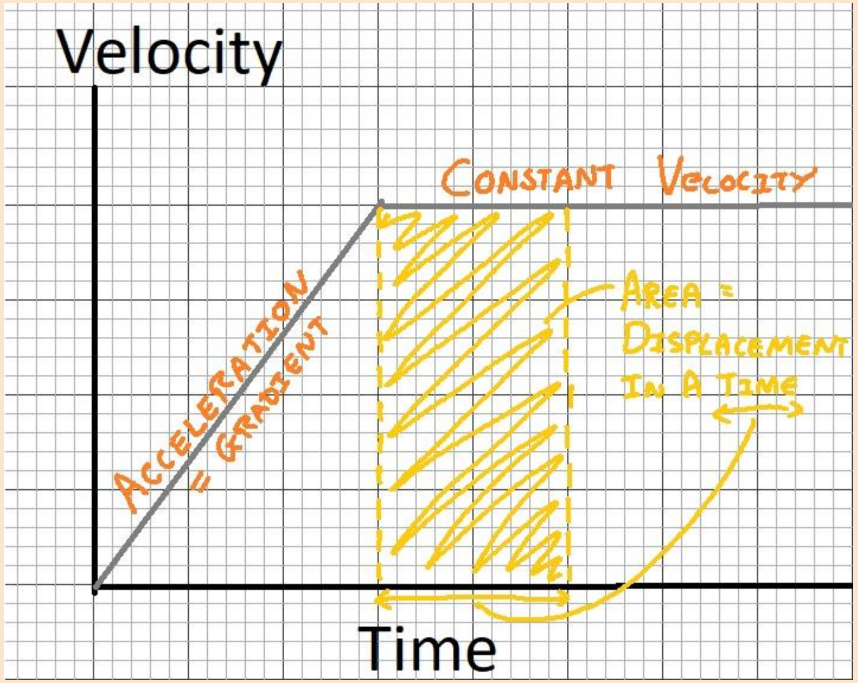
The larger the mass 'm' of an object, the larger the force 'F' that needs to be applied to reach the same acceleration 'a'.

$$F = m.a$$

Motion Graphs

The motion of an object can be illustrated on a motion graph.

A velocity vs time graph can be used to calculate acceleration (using the gradient) or the displacement (the area under the line).



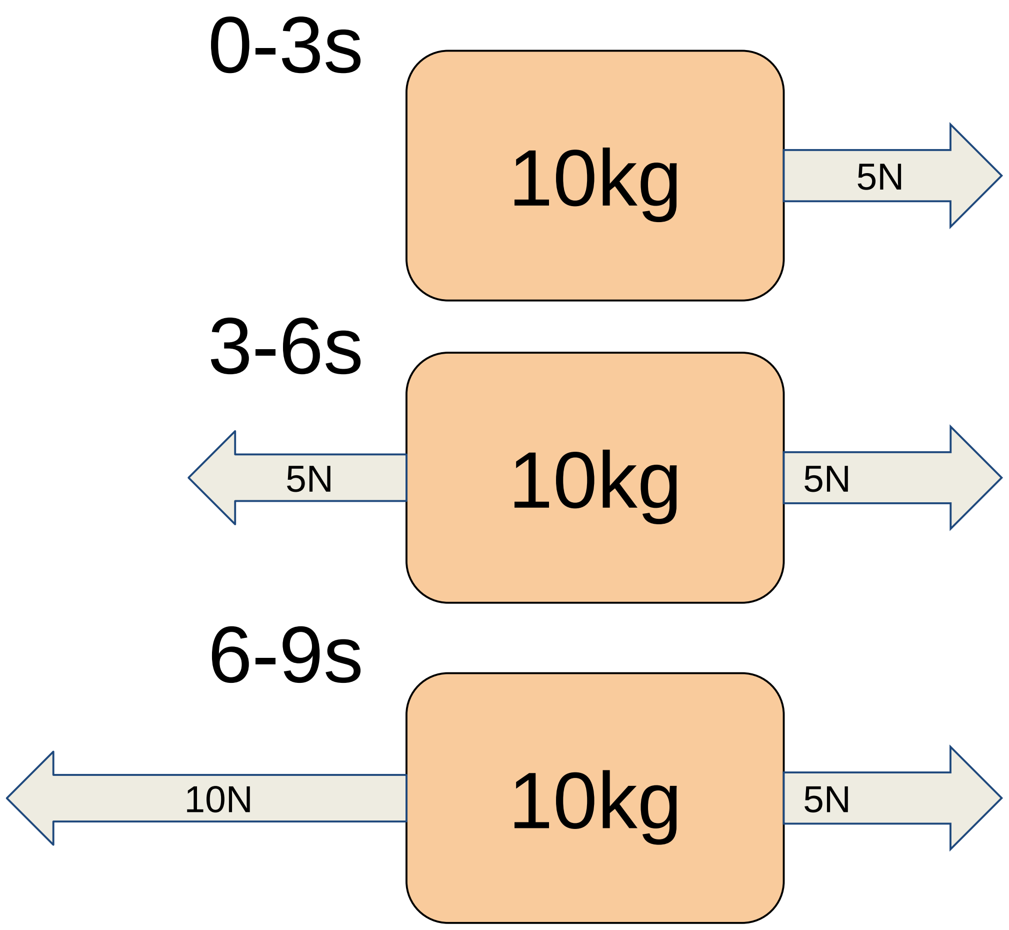
Essential Forces and Motion TASK

At 0s the 10kg mass pictured is stationary before a series of forces act upon it.

1. Describe the motion of the 10kg mass in each of the subsequent timeframes.
2. Where applicable calculate the initial velocity ‘u’, final velocity ‘v’ and acceleration ‘a’ of the mass using equations you recall from GCSE Science.
3. Sketch a velocity vs time graph for the complete 9 seconds.

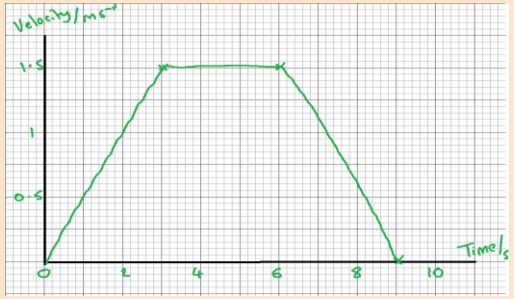
Going Deeper:

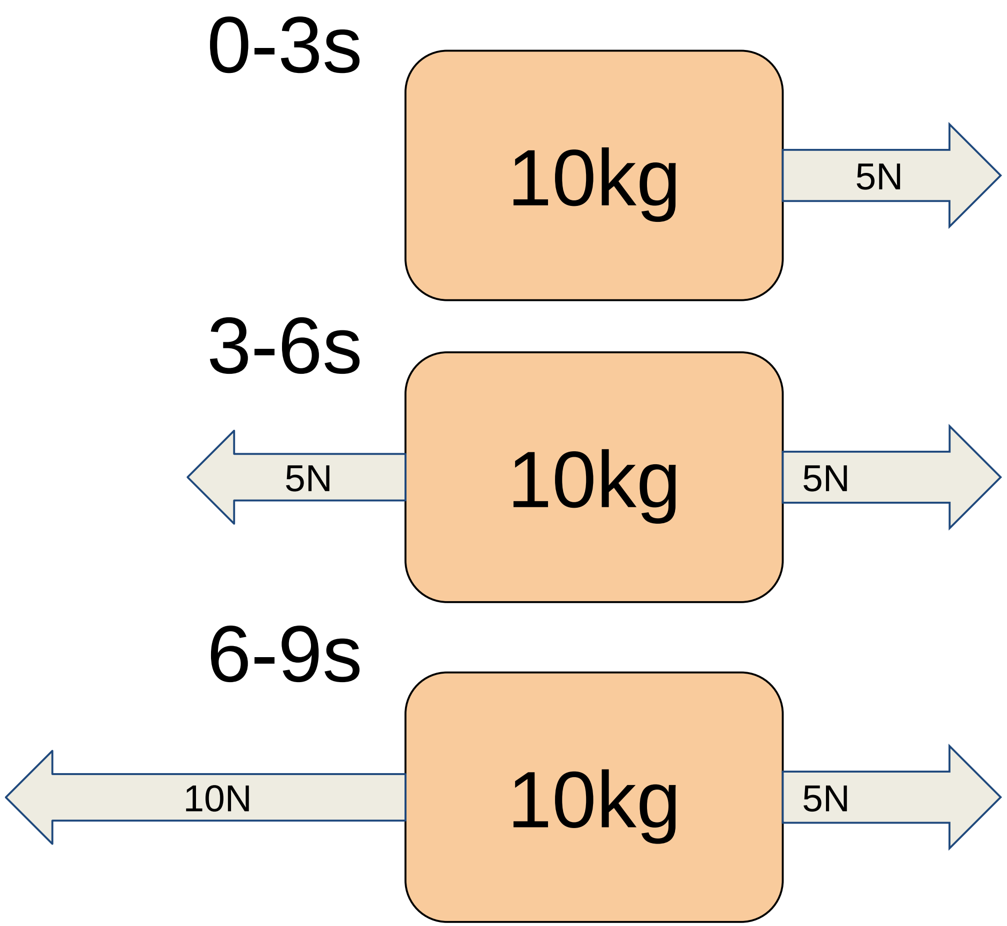
1. Use your graph to calculate how far the mass travelled in total.
2. Use your graph to derive an equation for the displacement ‘s’ of the mass after time ‘t’ given the initial 'u’ and final ‘v’ velocity.



Essential Forces and Motion TASK answers

1. Describe the motion of the 10kg mass in each of the subsequent timeframes.
   a. 0-3 Accelerating to right
   b. 3-6 Constant velocity
   c. 6-9 Deceleration (-ve acceleration)
2. Where applicable calculate the initial velocity ‘u’, final velocity ‘v’ and acceleration ‘a’ of the mass using equations you recall from GCSE Science.
   a. 0-3 u=0 v=1.5m/s
   b. 3-6 u=1.5m/s v=1.5m/s
   c. 6-9 u=1.5m/s v=0
3. Sketch a velocity vs time graph for the complete 9 seconds.





Essential DC Circuits

Current, Potential Difference and Resistance

Current ‘I’ is the rate of flow of charge ‘Q’ in a circuit. It is measured in Amps with an ammeter in series.

$$I = Q/t$$

Potential difference ‘V’ is a measure of how much energy ‘E’ is transferred by the charge ‘Q’ as it passes through a component in the circuit. It is measured in Volts with a voltmeter in parallel.

$$V = E/Q$$

The resistance ‘R’ of a component is a measure of how difficult it is for the current to flow. It is measured in Ohms ‘Ω’. A high resistance lowers the current. Components with a high resistance will take a larger share of energy in a loop of a circuit.

$$V = IR$$

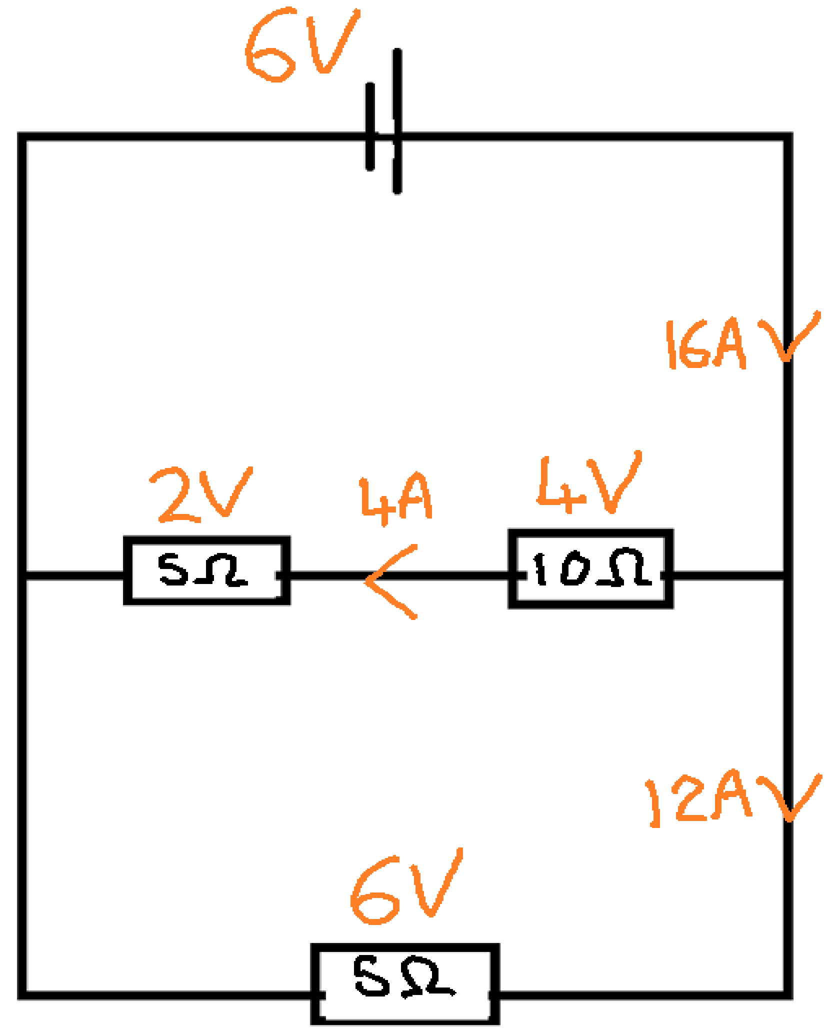
Essential DC Circuits

Series and Parallel Circuits

A series circuit is a single loop. The current is always the same at every point in the loop. The energy is shared between all components so the potential difference across each individual component will match the supply voltage of the cell.

A parallel circuit contains multiple loops. The current splits at a junction but is always conserved (the amount flowing in equals the amount flowing out). More current flows down the path of least resistance.

Each loop in the circuit gets its own supply of energy to be shared.

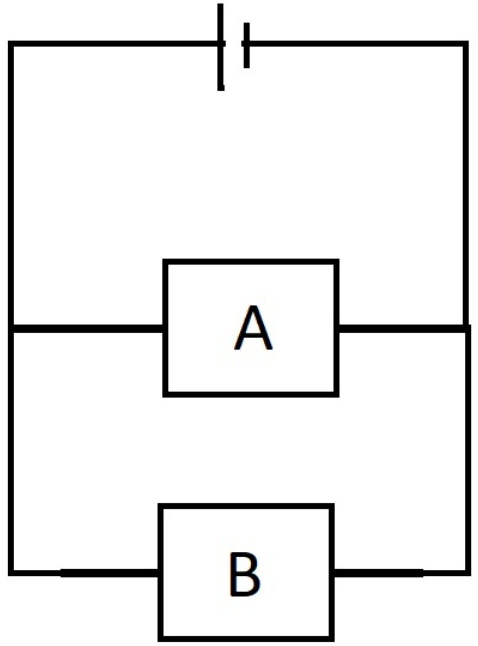


Essential DC Circuits TASK

1. Sketch and label as many circuit symbols as you can remember from GCSE Science.
2. Describe a simple experiment that you could perform to calculate the resistance of component B.
3. Complete the following table, add units to each column heading.

Component	Current flowing through it	Potential difference across it	Resistance
A	0.1		
B	0.4		

6V Cell



Going Deeper

- What current would be flowing through the cell?
- Can you write down any rules that define the behaviour of current and potential difference in series and parallel circuits?
- The circuit model we have used assumes the cell has no resistance. If the cell had resistance what would happen to the potential difference across the components if there resistance was lowered?

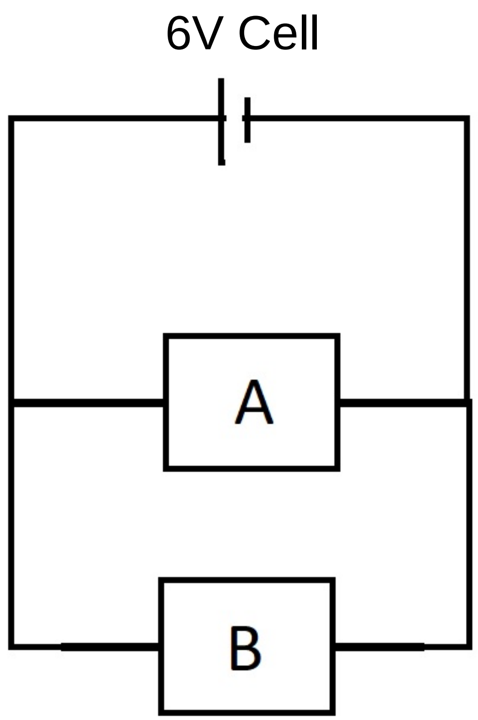
Essential DC Circuits ANSWERS

1. Circuit symbols correct
2. Describe a simple experiment that you could perform to calculate the resistance of component B.

   Connect ammeter in series measure current
   Connect voltmeter in parallel - measure p.d.
   Use Ohm’s Law - V = IR
   EXT - Use variable resistor to vary current and plot IV graph with gradient giving resistance

3. Complete the following table, add units to each column heading.

Component	Current flowing through it	Potential difference across it	Resistance
A	0.1	6	60
B	0.4	6	15



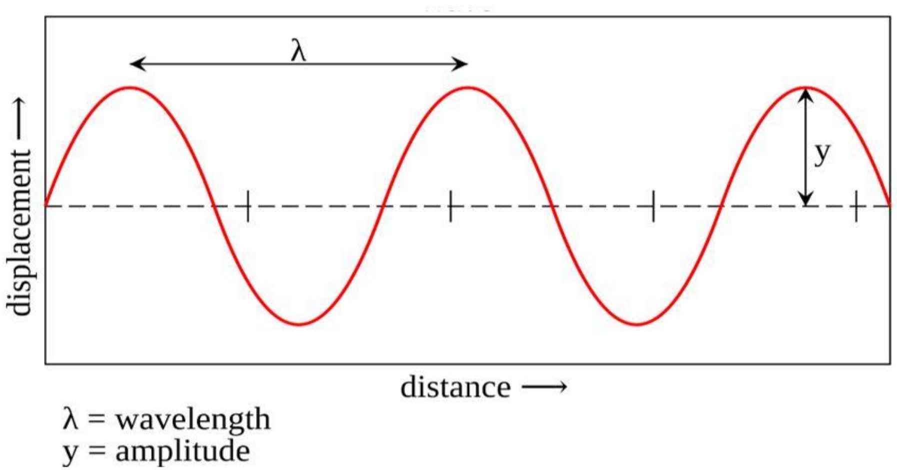
Essential Waves

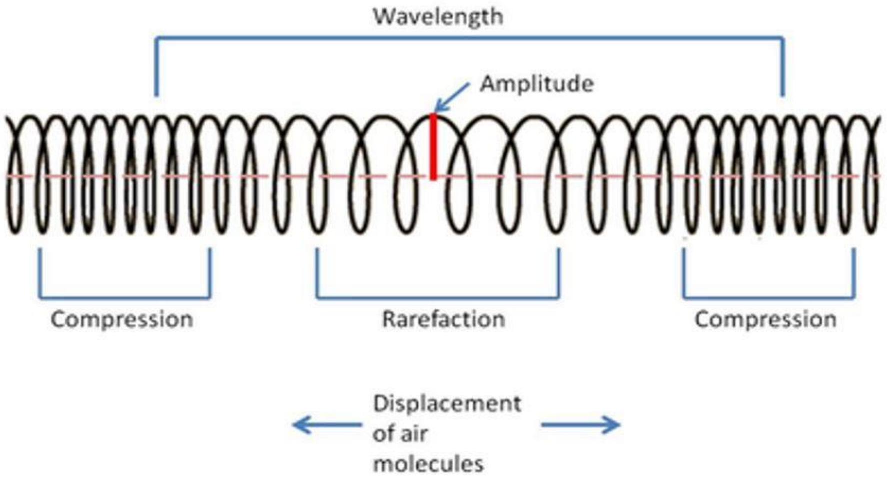
What is a Wave?
Waves transfer energy without transferring matter.
Light and sound are common examples of waves.
A wave can be thought of as a series of oscillations.

There are several wave features that you should be able to recall from GCSE Science:

- Wavelength - the distance between two identical points on the wave.
- Amplitude - the maximum displacement of the waves oscillation
- Frequency - the number of oscillations per second, measured in Hertz.

The wave equation links the wave speed 'c' to its frequency 'f' and wavelength 'ƛ': **$c = f ƛ$**





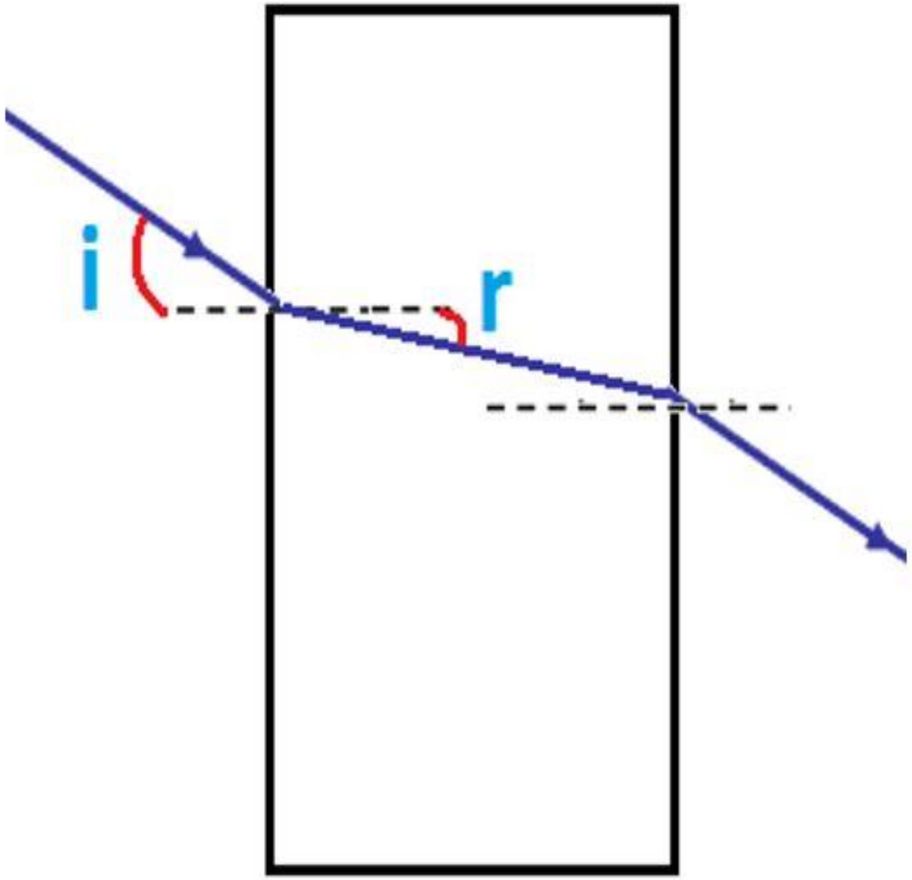
PiXL Science

Wave Properties

Waves can be **reflected** - the wave hits a boundary between materials and it returns back into the same material.

Waves can be **refracted** - when it enters a new medium its direction can change. The wave speed and wavelength change but the frequency remain the same.

Waves can be **diffracted** - when a wave encounters an object that is of comparable size to its own wavelength, the wave spreads out.



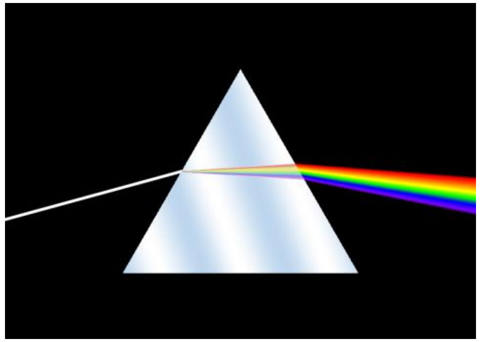
Essential Waves TASK

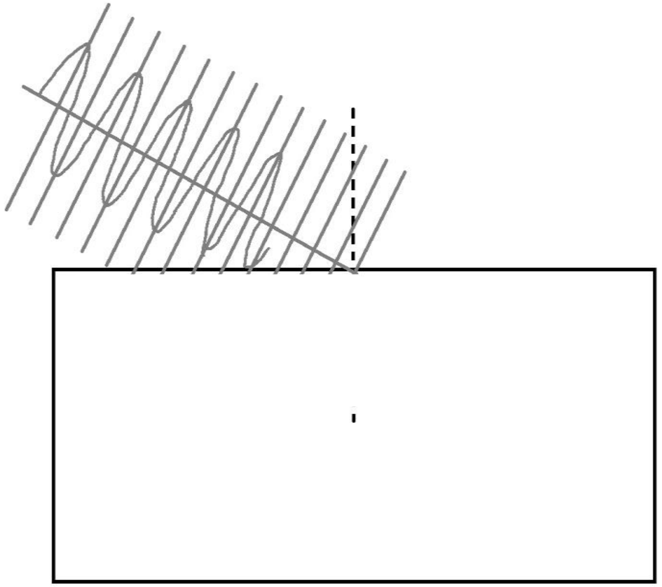
1. Recall the wave equation that links wavelength, frequency and wave speed and state the unit of each quantity.
2. Onto your copy of the diagram label a wavelength and the amplitude of the wave.
3. Describe what will happen to the wave speed as the wave progresses into the glass block from the surrounding air. Can you complete the sketch in as much detail as possible (pay attention to the wavelength)?
4. What is the name given to this phenomena - where a wave changes direction as a result of a change in wave speed? What other phenomena are associated with waves?

Going Deeper:

By referring to the diagram of a prism, can you describe how the wavelength of light affects the amount of refraction it experiences?

A traditional filament light bulb will emit a complete spectrum including electromagnetic waves outside of the visible region. How and where would you expect to detect these waves if this light was also passed through a prism?





Essential Waves ANSWERS

1. Recall the wave equation that links wavelength, frequency and wave speed and state the unit of each quantity.

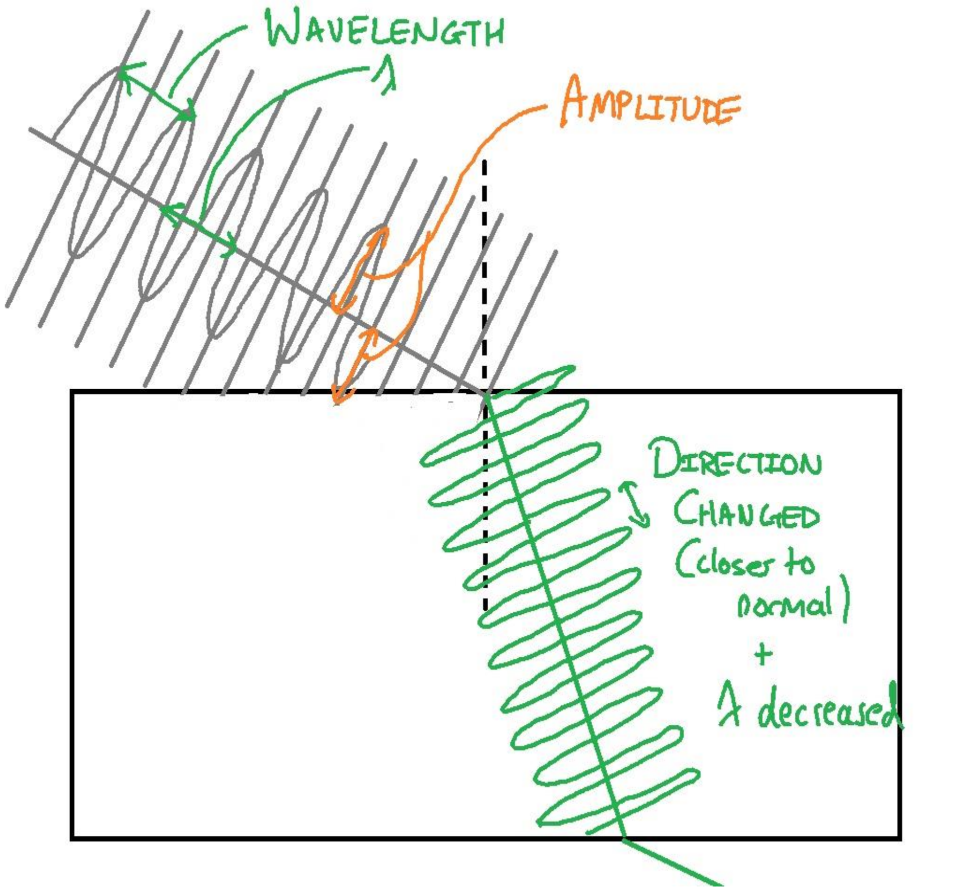
Wavespeed (m/s) = Frequency (Hz) X Wavelength (m)

2. Onto your copy of the diagram, label a wavelength and the amplitude of the wave. **See diagram**

3. Describe what will happen to the wave speed as the wave progresses into the glass block from the surrounding air. Can you complete the sketch in as much detail as possible (pay attention to the wavelength)? **See diagram - speed decreased, wavelength decreases**

4. What is the name given to this phenomena - where a wave changes direction as a result of a change in wave speed? What other phenomena are associated with waves?

Refraction (shown in diagram), Reflection, Diffraction and Polarisation (going deeper)



Essential Practical Skills for A Level Physics

Practical skills are essential for A-Level Physics!

Practical investigations form a very important part of the course. As well as being assessed in your actual exams you will also have your practical skills assessed in a series of required practical investigations.

This lesson summarises the skills you should have already gained from GCSE and helps you to make a strong start in A-Level Physics.

PiXL
partners in excellence

Recording Data

Missing units - Every column heading must have units.

Inconsistent precision - Each measurement should be made to the same level of precision.

Increased significant figures – A calculation answer cannot have more significant figures than the numbers used in it. Here the average has more s.f. than the repeats.

Incorrect mean – The mean should be calculated ignoring any anomalies.

Time	Distance Travelled (m)				Average Speed (ms^{-1})
	Repeat 1	Repeat 2	Repeat 3	Average	
5	7	5	7	6.33	1.27
10	15	13.2	16	14.73	1.473
15	20	21.6	21	20.87	1.391
20	22	22.1	35	26.37	1.318

Spot the 4 deliberate mistakes in the results table - (HINT - Only 1 mistake is a type of calculation error)

Going deeper… How could the table be improved further? Can you write a set of table rules?

Rules for Results Tables

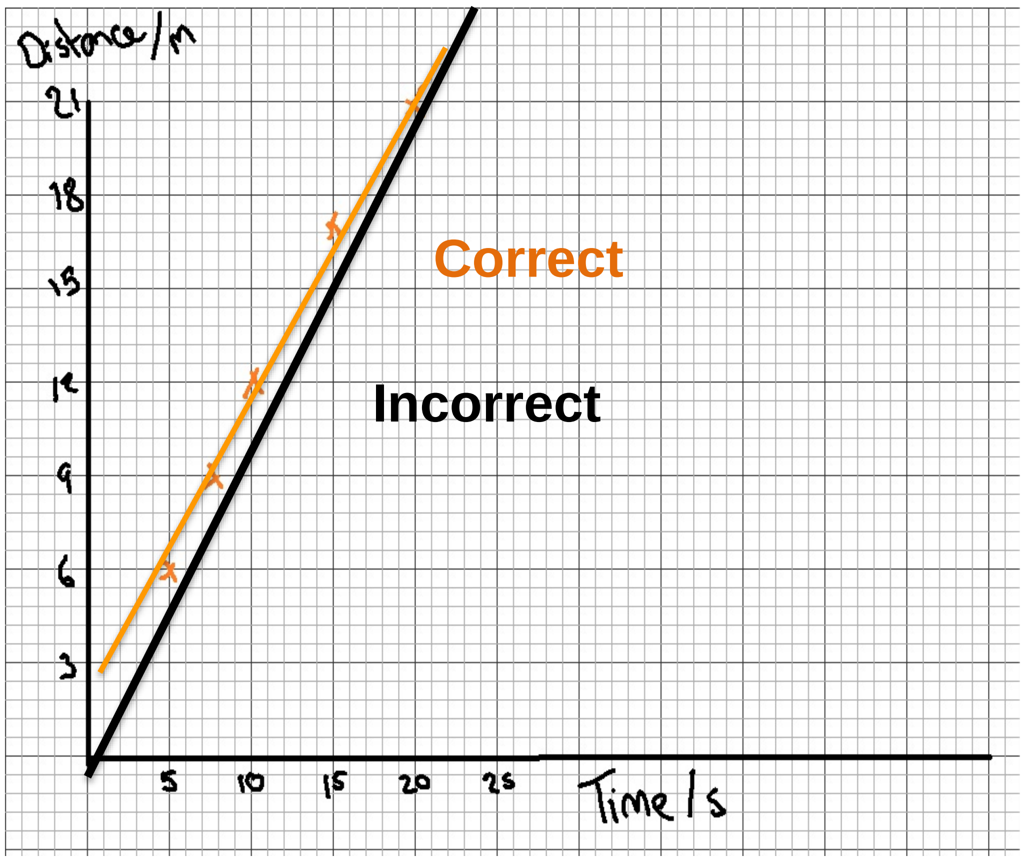
1. Tables should have clear headings with units indicated using a distinguishing mark before the unit, e.g. / or ()
2. It is good practice to draw a table before an experiment commences and then enter data straight into the table.
    a. This may mean that you record results in an non-ascending or descending order which is fine when working in a lab book.
    b. If you were to present the table or to use it to identify patterns, rewriting in ascending or descending order after the experiment would be helpful.
3. The independent variable should be in the left hand column.
4. The body of the table should not contain any units
5. Data within a column should be recorded to the same number of decimal places which is determined by the resolution of the measuring instrument used.
6. Any data which is a calculation from other data in the table should not be recorded to more significant figures.

Adapted from AQA Practical Skills Handbook.

Going deeper - What is the uncertainty in your measurement? This is determined by the resolution of your measuring instrument and could be recorded along with the heading and unit too!

Rules for Graphing

1. Axis should be labelled with a unit which is separated by a distinguishing mark, e.g. / or ()
2. Data points should only be plotted using x or +.
3. The **plotted points** should occupy as much of the graph paper as possible in both the x and y directions.
    a. Use at least half of the graph paper in both the x and y direction
    b. Use a sensible scale - multiples of 1,2,5,10,20,50 etc.
    c. Axis do not have to start at (0,0) but be careful if you need to work out the y-intercept.
4. A line of best fit should be drawn
    a. Use a thin pencil line
    b. Ignore anomalies and don't force it through every plotted point
    c. Have roughly the same number of points on either side
    d. Not all line of best fits go through the origin (0,0) so don't force it!



Types of Error

Random errors

- Unpredictable and vary from measurement to measurement.
- Random errors are always present.
- They cause readings to be spread around the true value.
- Their effects can be reduced by taking multiple repeated measurements and calculating a mean.

Systematic errors

- A systematic error is the same for each measurement made.
- It occurs when there is a problem with the measuring instrument e.g. a zero error; or the observation technique e.g. reading the wrong scale; or a problem with the environment e.g. the experiment was not conducted at standard temperature and pressure.
- The whole experiment should be repeated using a different technique/instrument if a systematic error has occurred.

Sort the following into systematic and random errors:

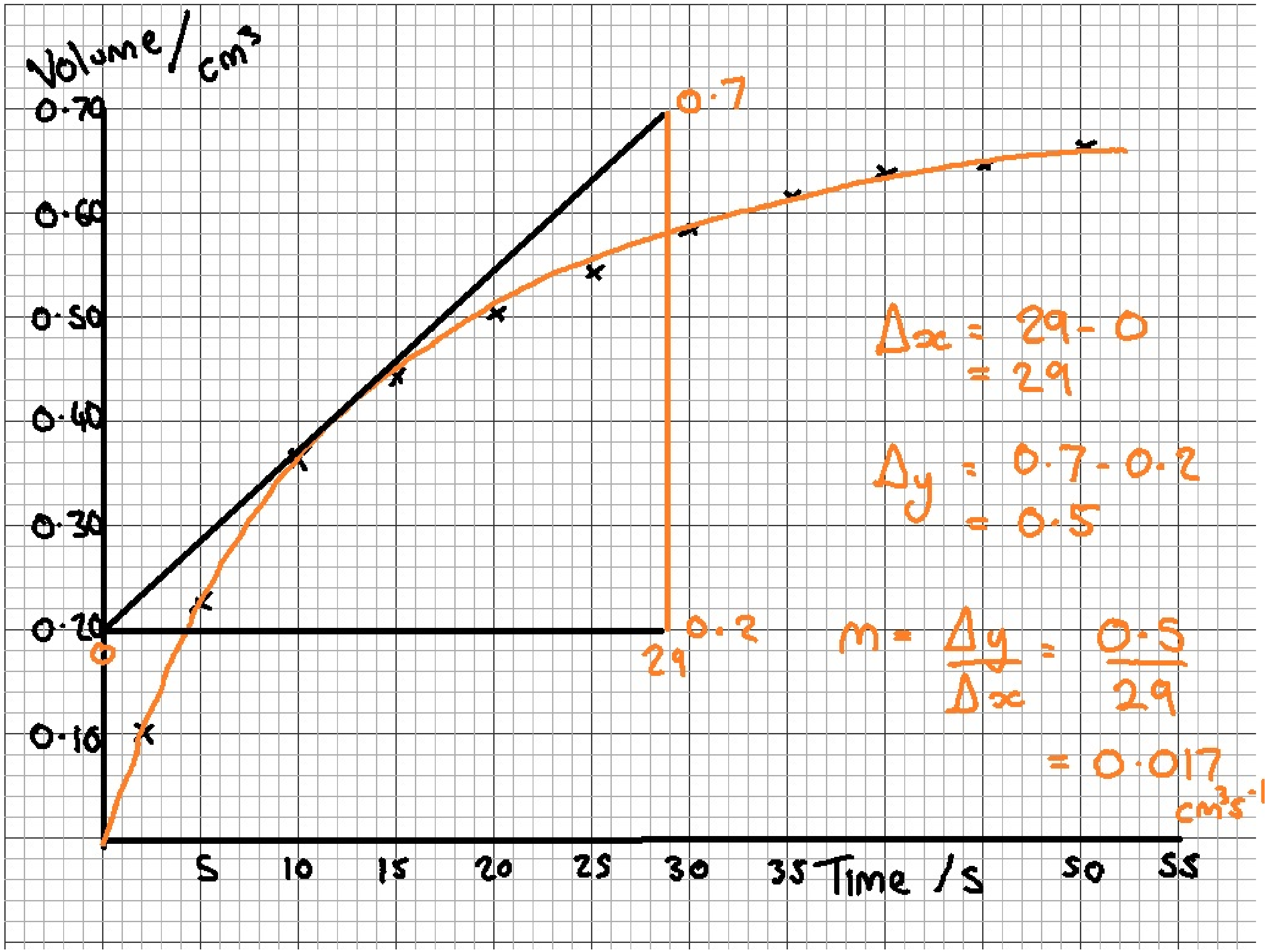
1. Parallax error when measuring the meniscus on water in a measuring cylinder.

2. A faulty analogue ammeter that has a reading of 0.1A when it is not connected in a circuit.

3. Human reaction time error using a stopwatch to time the drop of a tennis ball from the ceiling to the floor.

Going deeper: How would you resolve these errors?

Finding the Gradient



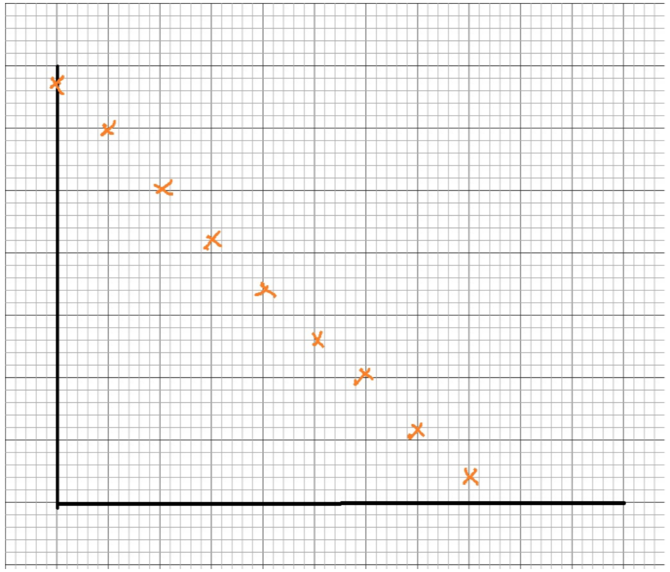
- When finding the gradient 'm' of a line always show your working and always draw a triangle!
- The hypotenuse of the triangle should always be at least as big as half of the line of best fit.
- If the line of best fit is a curve, draw a tangent to the curve at the point where the gradient is required.
- The gradient 'm' can be calculated by:

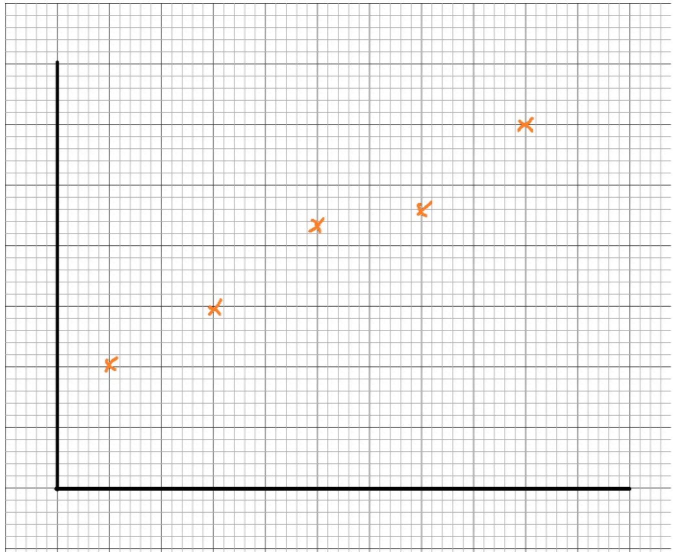
  m = change in y / change in x
  = Δy / Δx

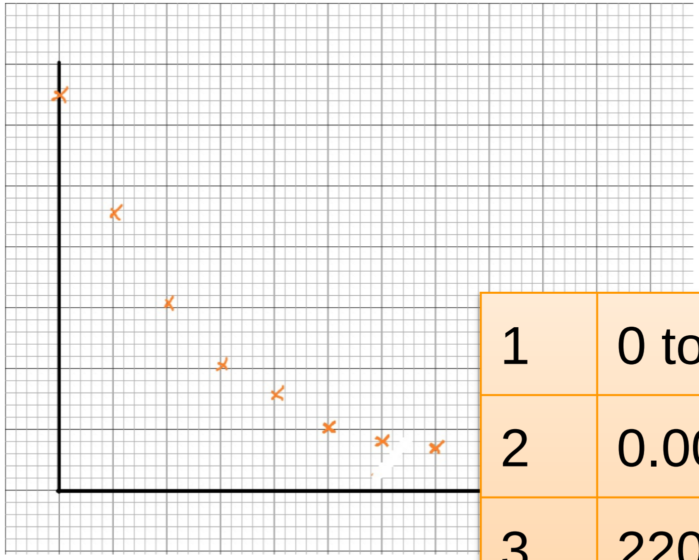
- The unit for the gradient is the unit for the y-values divided by the unit for the x-values.

Graphing Challenge

- Add a random selected range to the x and y axis by rolling a dice. Don't worry about units!
- Create a line of best fit on your graph
- Measure the gradient (use a tangent for the curve). Don't worry about units!







1	0 to 100
2	0.001 to 0.010
3	2200 to 6700
4	0 to - 100
5	0 to - 0.025
6	10000 to 10010

Going Deeper
Sketch the graph with a large random error and suggest how it could be dealt with .
Can you work out the y-intercept from your graph?

Using the Equation of a Line

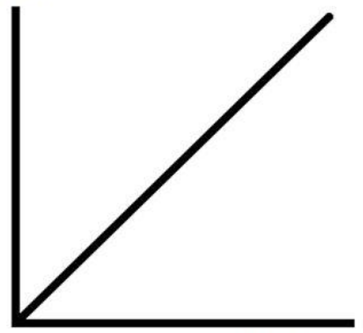
$y = mx+c$

y= y variable

x=x variables

m= gradient

c= y intercept



1. Find a physics equation that matches the variables used in your experiment.
2. Re-arrange it into the form y=mx+c
3. Match up the values to determine what the gradient of your graph and the y-intercept represent

Worked example:

y-axis = current 'I'

x-axis = voltage 'V'

Equation with both : V = IR

Re-arrange to make I subject:

$$I = \frac{1}{R}V$$

Match: $y = mx + c$

y-axis quantity	x-axis quantity	Gradient (m)	y-intercept (c)
Q (charge)	T (time)	I (Current)	0
v^2	s	a	u^2

Summary Quiz

1. Calculate the mean of this set of data: 0.12, 0.14, 0.11

2. Define what is meant by a random error

3. State 4 rules for graphing

4. If a student had plotted a graph of force, applied ‘F’ to a spring on the x-axis and extension ‘e’ of the spring on the y-axis, what would the gradient represent? (F= ke)

Summary Quiz Answers

1. Calculate the average to this set of data: 0.12, 0.14, 0.11

   0.12

2. Define what is meant by a random error.

   An error that is always present and varies from reading to reading causing a spread of results about a true value OWTTE.

3. State 1 of the 4 rules for graphing.

   Axis should be labelled with a unit which is separated by a distinguishing mark, e.g. / or ()

   Data points should only be plotted using x or +.

   The plotted points should occupy as much of the graph paper as possible in both the x and y directions.

   A line of best fit should be drawn

4. If a student had plotted a graph of force, applied ‘F’ to a spring on the x-axis and extension ‘e’ of the spring on the y-axis, what would the gradient represent? (F= ke)

   1/k

Essential Mathematics for A Level Physics

Essential Maths

At least 40% of the marks in the examinations will require the use of mathematical skills.

Standard form, prefixes and significant figures.

You need to be able to use standard form and recognise common prefixes.

1) Calculate the following and express your answer in standard form **and** as an ordinary number:

a) $(2.02 \times 10^4) \times (3.50 \times 10^2)$ b) $5.2 \times 10^{-2} / 1.4 \times 10^3$ c) $0.002750 + 4.20 \times 10^{-3}$

2) Calculate the following, express your answer in standard form in SI units (m^2).

a) 5.6cm x 7.1nm b) 9.3mm x 2.4Mm c) 3.1 µm x 1.6Gm

Standard form, prefixes and significant figures

1a) 7.1×10^{6} or 7 100 000

b) 3.7×10^{-5} or 0.000037

c) 6.95×10^{-3} or 0.00695

2a) 4.0×10^{-10} m^2

b) 2.2×10^{4} m^2

c) 4.3×10^{3} m^2

Remember that all answers should be given to the **same number of significant figures as the question**. You can never be more precise than the data you are given, but **round at the end of a multistep calculation** to avoid rounding errors.

Rearranging equations

This is a GCSE skill that is vital for success in Physics

1) Make ‘m’ the subject in these equations:

a) F = m a   b) E = m g h   c) $E = \frac{1}{2}mv^2$

2) Solve the following:

a) sin x = 0.5   b) $\cos 25 = \frac{11}{x}$ c) $2.5 = \frac{1.3}{\sin x}$

Going deeper:

Rearrange to find ‘a’:

$v^2 = u^2 + 2as$

$s = ut + ½ at^2$

Beyond expected knowledge:

What does ‘x’ equal?

$4 = 10^x$

Rearranging equations

1) a) $m = \frac{F}{a}$ b) $m = \frac{E}{g\,h}$ c) $v = \sqrt{\frac{2E}{m}}$

2) a) 30^0 b) 0.91 c) 31

Going deeper:

1) $a = \left(\frac{v^2 - u^2}{2s}\right)$

2) $a = \left(\frac{s - ut}{{}^1\!/_2\, t^2}\right)$

Beyond expected knowledge:
What does ‘x’ equal?
0.6

Trigonometry

1) Find, by calculation or scale drawing,

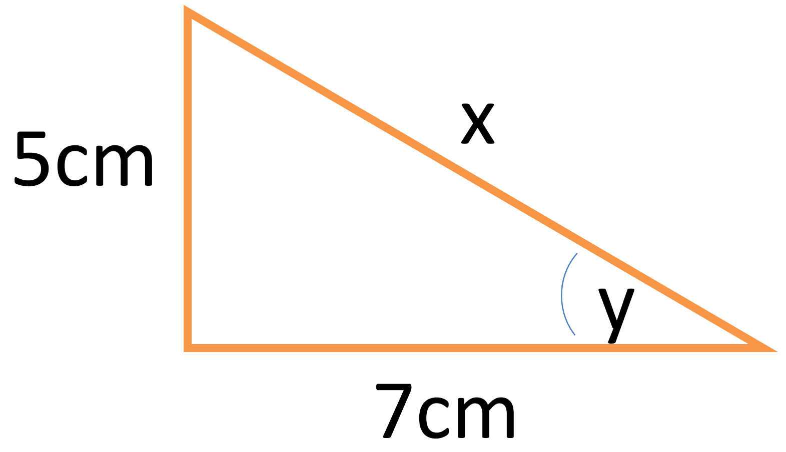
a) the length of side ‘x’

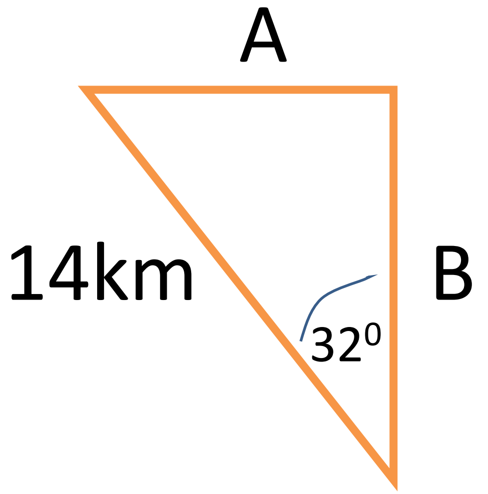
b) the angle ‘y’

2) Find, by calculation or scale drawing,

a) the length of side ‘A’

b) the length of side ‘B’





Going deeper: How would your answers change if:

- in Q1 the length of the shortest side doubled?
- in Q2 the angle halved?

Trigonometry

1a) $x^2 = 5^2+7^2$

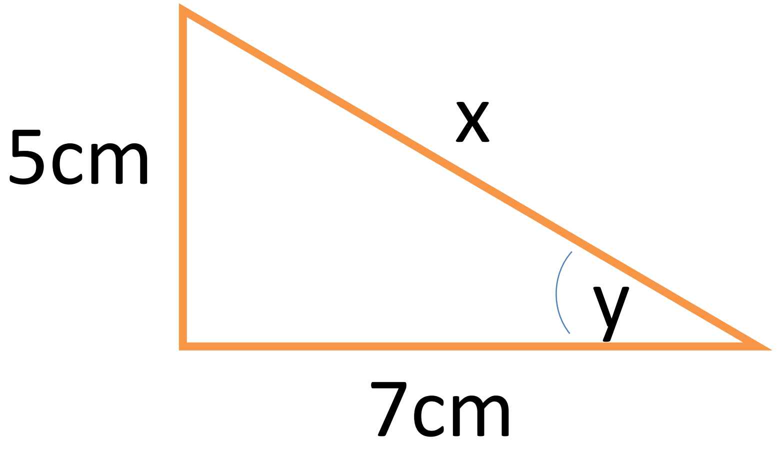
$x = 8.6$cm

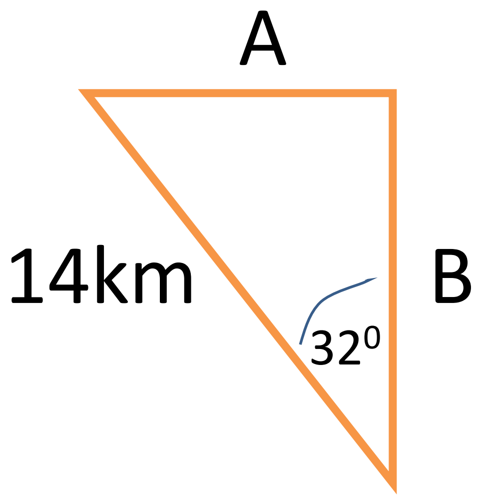
b) the angle 'y' = 36^0

2a) sin32=A/14

A= 7.4km

b) B = 12km

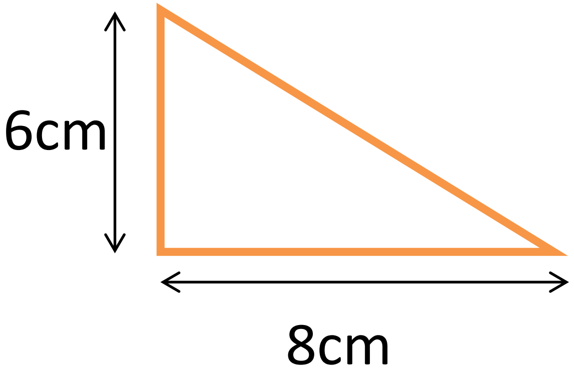


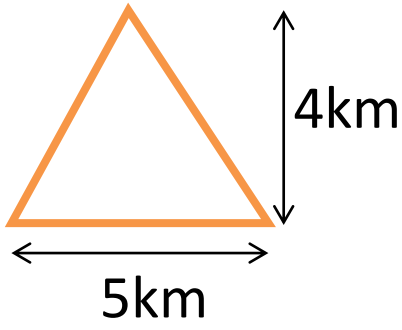


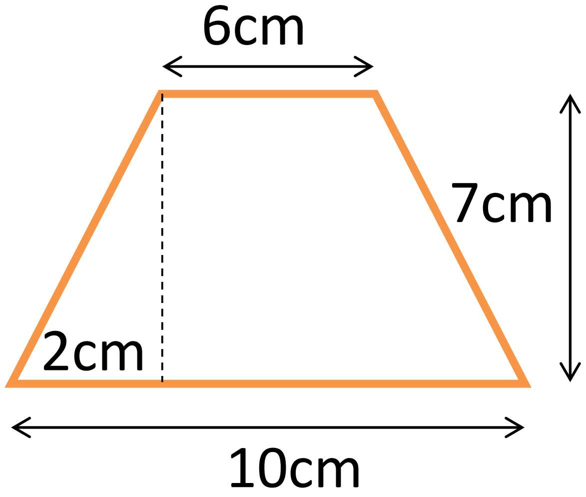
Extension: 1a) 12cm b) 55^0 2a)3.9km b) 13km

Geometry

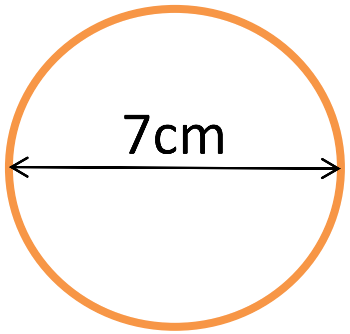
Calculate the area of the shapes below. (Going deeper: convert answers to m^2)

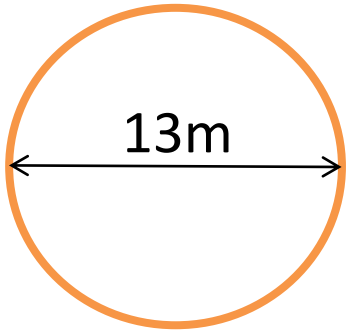




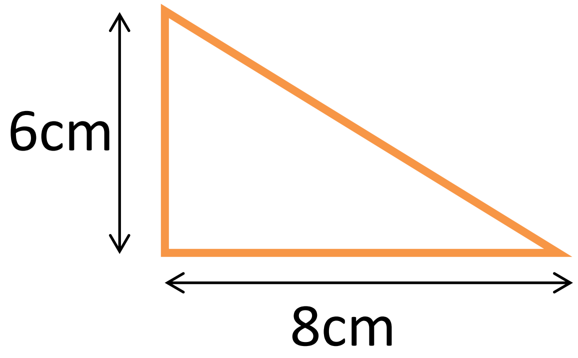


Calculate the circumference and area of the circles below



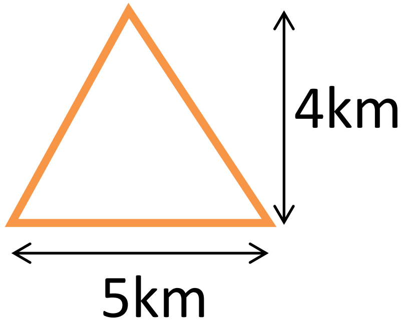


Geometry



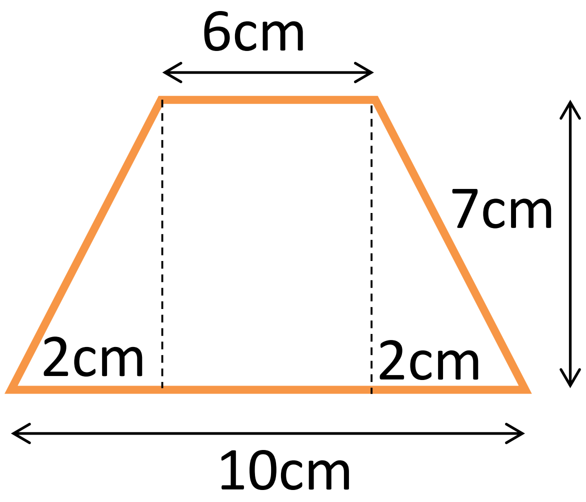
24 cm^2

2.4×10^{-3} m^2



10 km^2

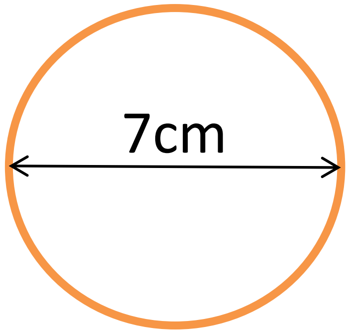
1×10^7 km^2



56cm^2

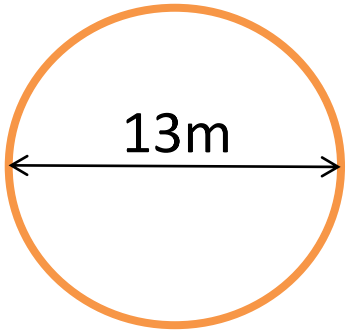
5.6×10^{-3} cm^2

Calculate the circumference and area of the circles below



22cm

38cm^2



41m

130m^2

Units

You need to use correct units in calculations and convert units. Below are the five 'base' or S.I units you will use this year. You need to be able to convert and recognise units in S.I units

Quantity	S.I Unit
electric current	A
temperature	K
time	s
length	m
mass	kg

1) Force = Change in momentum/time
Write the unit for Force, Newtons, in S.I units

2) Convert 10km/hour into S.I units

3) Kinetic energy can be calculated using $E = \frac{1}{2}mv^2$
Write the unit for energy, Joules, in S.I units

4) Which of these is a correct unit of power?
a) Js b) $kgm^{-1}s^{-2}$ c) Nm d) $kg\ m^2\ s^{-3}$

Going deeper: Write down as many different units for a) energy and b) power as you can

Units

1) Write the unit for Force, Newtons, in S.I units $kg\ ms^{-2}$

2) Convert 10km/hour into S.I units 2.8m/s

10 000m/hour = 166.67m/minute = 2.8m/s

3) Write the unit for energy, Joules, in S.I units $kg\ m^2 s^{-4}$

4) Which of these is a correct unit of power?

a)Js b) $kgm^{-1}s^{-2}$ c) Nm d) $kg\ m^2\ s^{-3}$