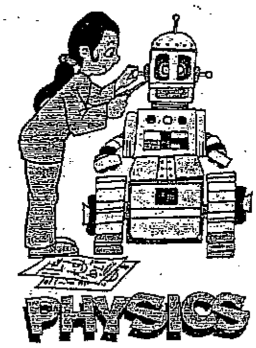
Name ______________________________

Tutor Group ___________



Bridging the Gap

Physics

The work in this booklet is based on assumed prior knowledge from GCSE. You should attempt it to the best of your ability, using whatever resources you can.

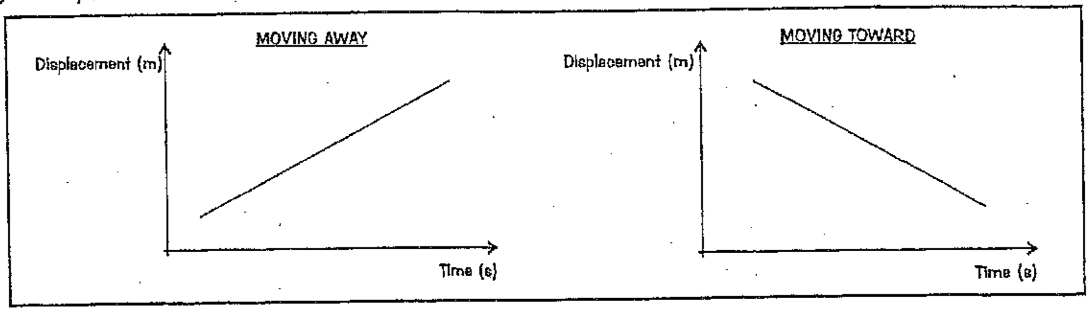
Any areas for development that you identify should be raised with your teacher when you <u>hand it in to the teacher of your first lesson in September.</u>

Please attempt all tasks, writing the working out and answers on lined A4 paper, unless otherwise instructed. Put your name on all sheets of paper used.

Displacement-Time Graphs

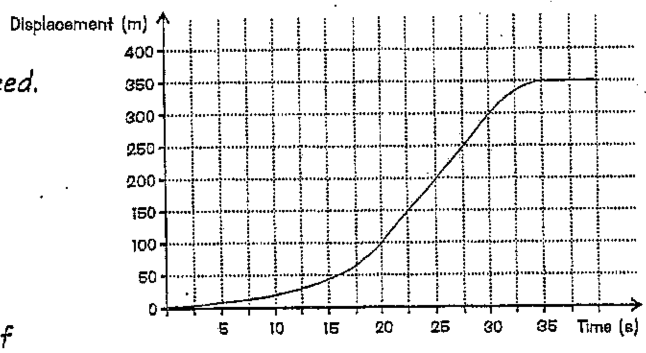
Drawing Graphs to Show How Far Something Has Travelled

A graph of displacement against time tells you how far an object is from a given point, in a given direction, as time goes on. As the object moves away from that point the displacement on the graph goes up, and as it moves towards it the displacement goes down:



Importantly, these graphs only tell you about motion in one dimension — for example, they can tell you how far up a ball has been thrown, but not how far it has moved horizontally.
You can use these graphs to calculate the velocity of an object (in the given direction).

This example shows the displacement-time graph for a cyclist accelerating to a constant speed and then braking.



You can read the following directly off the graph:

1) He took 20 seconds to accelerate to full speed.
2) He travelled 100 metres in that time.
3) He travelled at constant velocity for the next 10 seconds.
4) He travelled 200 metres in that time.
5) He took 5 seconds to stop fully.
6) He travelled 50 metres in that time.
7) He remained stationary at a displacement of 350 metres from his starting point.

You can work out three more details of the cyclist's journey:

1) The value of the constant velocity he had between 20 and 30 seconds.
2) His average velocity for the whole journey.
3) His average speed for the whole journey.

When an object is travelling at a steady velocity its displacement-time graph is a straight line, with a gradient equal to the velocity.

$$\text{velocity } (ms^{-1}) = \text{gradient} = \frac{\text{change in distance travelled (m)}}{\text{change in time (s)}} = \frac{300\text{ m} - 100\text{ m}}{30\text{ s} - 20\text{ s}} = \frac{200\text{ m}}{10\text{ s}} = \boxed{20\ ms^{-1}}$$

To calculate the average speed for the whole journey we use the formula:

$$\text{average velocity } (ms^{-1}) = \frac{\text{total displacement (m)}}{\text{total time taken (s)}} = \frac{350\text{ m}}{35\text{ s}} = \boxed{10\ ms^{-1}}$$

$$\text{and, average speed } (ms^{-1}) = \frac{\text{total distance travelled (m)}}{\text{total time taken (s)}} = \frac{350\text{ m}}{35\text{ s}} = \boxed{10\ ms^{-1}}$$

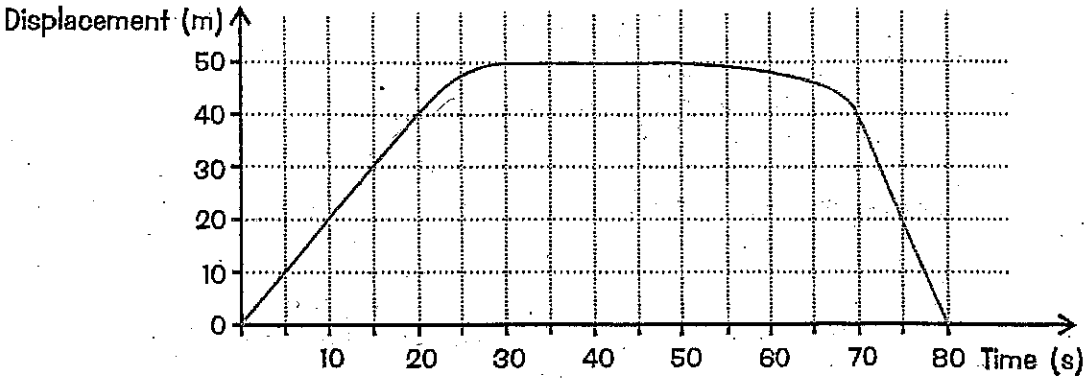
In this case, the average speed is the same as the average velocity, because the car doesn't change direction. The total distance is the +ve displacement plus the -ve displacement.

Displacement-Time Graphs

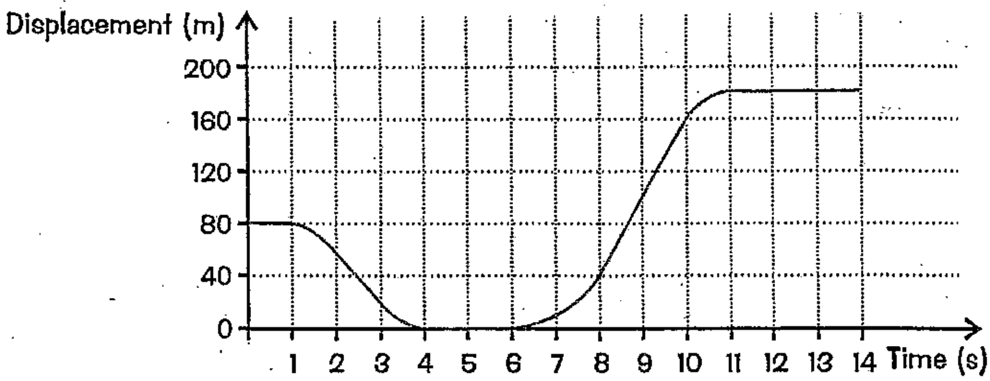
Have a go at analysing these graphs:

Write down as much as you can about the motion of the objects represented by the following graphs. Work out any steady velocities, the average velocity and average speed for each journey.

Graph 1:



Graph 2:



Work

Work Done = Increase in Gravitational and Kinetic Energy

Here are three possible situations:

1) The work done goes entirely into the gravitational potential energy of an object.
E.g. if you are lifting an object straight upwards.

Work done = force × distance
= weight of object × height lifted
= mass of object × gravitational field strength × height

So: work done = mgh = the increase in gravitational energy

2) The work done goes entirely into the kinetic energy of an object.
E.g. if a 5 newton force acts on a 3 kilogram body over a distance of 10 metres, what is its final speed if it was initially at rest?

Work done = increase in kinetic energy

$F \times d = ½ \times m \times v^2$. Dividing both sides by m gives:

$(F \times d)/m = ½ \times v^2$. Multiplying both sides by 2 gives:

$2 \times (F \times d)/m = v^2$. Finally, taking the square root of both sides gives:

$v = \sqrt{(2 \times (F \times d)/m)} = \sqrt{(2 \times (5\ N \times 10\ m) / 3\ kg)} = \underline{5.8\ ms^{-1}}$

3) The work done goes into increasing both the kinetic and the gravitational energy.

Work done = increase in E_k + increase in E_p

$F \times d = ½ \times m \times v^2 + mgh$

Work done can also go into increasing the elastic potential energy of something (if you stretch or squash it).

Have a go at these questions:

1) A 100 newton force lifts a 5 kilogram object 2 metres. When the force is removed, the object continues to move upwards. Calculate: (a) the work done by the force; (b) the gain in gravitational potential energy (using $g = 9.8\ Nkg^{-1}$); (c) the gain in kinetic energy.
2) A 10 newton force pushes an object of mass 2 kilograms horizontally on a frictionless surface for 25 metres. Calculate: (a) the work done; (b) the final speed of the object if it was initially at rest.

Potential Difference

Potential Difference (Voltage) — Energy Per Unit Charge

In any circuit energy is transferred from the power supply to the components (lamps, motors etc.), where it's converted into other forms, e.g. light. This energy is carried around the circuit by the charged particles. If you think about one coulomb of charge flowing around a circuit then:

(a) The amount of energy it's given by the power supply is the voltage across the power supply.
(b) The amount of energy it gives to each individual component in the circuit is the voltage across that component.

In other words, the voltage, or potential difference, across a component is the amount of energy (in joules) that it converts for every coulomb of charge that passes through it.

Voltage across component = Energy converted / Charge that passes through it
(in volts) (in joules) (in coulombs)

Or, in symbols: $V = E/Q$

Here are a few examples:

1) A lamp gives out 10 joules of energy when 0.5 coulombs pass through it. What is the potential difference across the lamp?

$V = E/Q = 10\ J / 0.5\ C = 20\ V$

2) What is the maximum amount of energy an electric heater could produce at 200 volts if the amount of charge that passes through it is 10 coulombs?

$V = E/Q$. Multiplying both sides by Q gives $V \times Q = E$, so $E = 200\ V \times 10\ C = 2000\ J$

3) How much charge has passed through a 12 volt motor if the energy it has converted is 3 joules?

From example 2, $V \times Q = E$

Dividing both sides by V gives $Q = E/V$, so $Q = 3\ J / 12\ V = 0.25\ C$

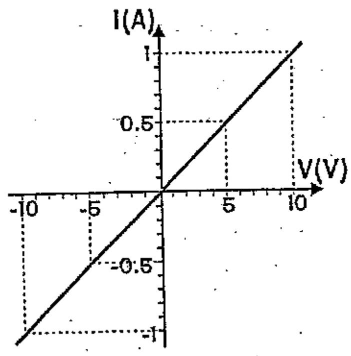
Have a go at these problems:

1) What is the maximum amount of energy that a lamp could give out if the voltage across it is 6 volts and the amount of charge that passes through it is 0.5 coulombs?
2) How much charge has passed through a circuit if 100 joules of energy have been converted across a potential difference of 8 volts?
3) An electric motor converts 1 joule of energy when 0.04 coulombs of charge pass through it. What is the potential difference across the motor?

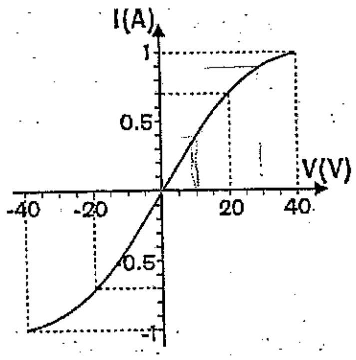
Resistance

Voltage-Current Graphs

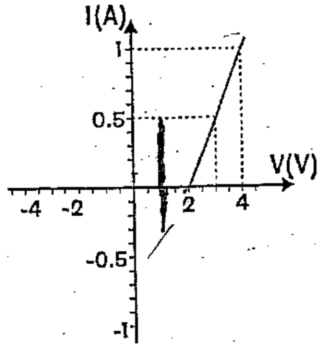
Look at the following graphs showing the current through different components as the voltage across them is changed (negative values refer to charges flowing the other way):



Resistor



Filament Lamp



Diode

We can use the graphs to determine the resistance at different voltages as follows:

Example:
What is the resistance of the resistor at:
(a) –10 V?
(b) –5 V?
(c) 5 V?
(d) 10 V?

(a) $R = V/I = -10\ V / -1\ A = 10\ \Omega$
(b) $R = V/I = -5\ V / -0.5\ A = 10\ \Omega$
(c) $R = V/I = 5\ V / 0.5\ A = 10\ \Omega$
(d) $R = V/I = 10\ V / 1\ A = 10\ \Omega$

Now you have a go at the other two:

1) *What is the resistance of the filament lamp at:*
(a) 10 V?
(b) 20 V?
(c) 30 V?
(d) 40 V?

2) *What is the resistance of the diode at:*
(a) 1 V?
(b) 2 V?
(c) 3 V?
(d) 4 V?

The Wave Equation

The Wave Equation Relates Speed, Frequency and Wavelength

For a wave of frequency f (in hertz), wavelength λ (in metres) and wave speed v (in metres per second) the wave equation is:

$$v = f \times \lambda$$

In other words:

speed (ms^{-1}) = frequency (Hz) x wavelength (m)

Look at these examples of using the wave equation:

1) *Sound is a longitudinal wave. If a sound has a frequency of 250 Hz and a wavelength of 1.32 metres, what is the speed of sound in air?*

   $v = f \times \lambda$, so $v = 250\ Hz \times 1.32\ m = 330\ ms^{-1}$

2) *All electromagnetic waves travel at $3 \times 10^8\ ms^{-1}$ in free space. If a radio signal has a wavelength of 1.5 kilometres, what is its frequency? (Hint: radio waves are a member of the electromagnetic spectrum.)*

   $v = f \times \lambda$. Dividing both sides by λ gives $v/\lambda = f$, so $f = v/\lambda = (3 \times 10^8\ ms^{-1}) / 1500\ m = 2 \times 10^5\ Hz = 200\ kHz$.

3) *If a wave has speed $50\ ms^{-1}$ and frequency 0.8 Hz, what is the wavelength?*

   $v = f \times \lambda$. Dividing both sides by f gives $v/f = \lambda$, so $\lambda = v/f = (50\ ms^{-1}) / 0.8\ Hz = 62.5\ m$.

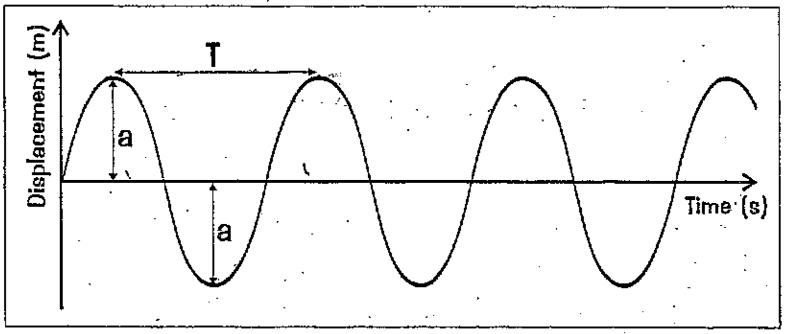
Now have a go at these questions:

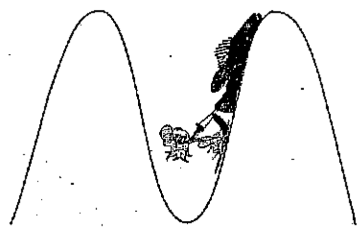
1) *What is the frequency of a water wave of wavelength 0.4 metres and wave speed $0.7\ ms^{-1}$?*
2) *What is the wavelength of radio waves of frequency 1×10^8 Hz? (Hint: speed of electromagnetic waves in free space = $3 \times 10^8\ ms^{-1}$.)*
3) *What is the speed of a wave of frequency 800 Hz and wavelength 2.5 metres?*
4) *What is the frequency of a sound wave of wavelength 0.25 metres? (Hint: speed of sound in air = $330\ ms^{-1}$.)*
5) *What is the speed of a wave along a spring if it has frequency 3 Hz and wavelength 1.4 metres?*
6) *What is the wavelength if the wave speed is $150\ ms^{-1}$ and the frequency is 600 Hz?*

Waves

Displacement-Time Graphs

As well as looking at a "snapshot" of a whole wave (displacement-distance graphs) you can consider just one point on a wave and plot how its displacement changes with time.





Time period (symbol, T) = the time for one complete oscillation of one point on the wave, measured in seconds.

Have a go at these questions:

1) *Sketch a graph of the displacement against distance for two complete wavelengths of a wave of amplitude 0.2 metres and wavelength 1.5 metres.*
2) *Sketch a graph of the displacement against time for two complete oscillations of one part of a wave of amplitude 0.6 metres and time period 2 seconds.*
3) *Sketch a graph of the displacement against distance for five full wavelengths of a wave with amplitude 0.01 metres and wavelength 0.02 metres.*
4) *Sketch a graph of the displacement against time for five complete oscillations of one part of a wave of amplitude 0.05 metres and time period 0.8 seconds.*