De Lisle College: Preparing for A Level Physics Class of 2024

Threshold Concept	Description	Task title	Mastery R/A/G	Date
1	Foundations of physics	• Knowledge organiser for basic facts		
2	Maths skills for physics	• Rearranging equations • Trigonometry • Standard form		
3	Energy and electricity	• Energy stores and systems • Rules for series and parallel circuits		
4	Particle model and radiation	• Structure of the atom • Radioactive decay		
5	Waves and electromagnetism	• Properties of waves • Electromagnetic induction		
6	Forces and motion	• Equations of motion • Forces and resultant forces		

Resources to use:

- **Specification**
  Edexcel AS and A level Physics 2015 | Pearson qualifications
  Our course starts on p26 of this specification.
- **Head start to A-level physics**
- Head Start to A-Level Physics (with Online Edition): bridging the gap between GCSE and A-Level (CGP Head Start to A-Level) : CGP Books, CGP Books: Amazon.co.uk: Books
- **A-level physics online**
  https://www.alevelphysicsonline.com/edexcel
  Seneca online learning – GCSE & A level –
  You **do not** have to complete all this assignment. It is to give you a flavour of the course content.
  https://app.senecalearning.com/dashboard/class/g8j9bz8zgc/assignments/assignment/adfce744-2188-4e0e-88cc-c7ff0e90d2bf
- **Maths skills for physics**
  A-Level Physics: Essential Maths Skills: superb for the 2023 and 2024 exams (CGP A-Level Essential Skills): Amazon.co.uk: CGP Books, CGP Books: 9781782944713: Books
- **GCSE revision guides & class notes alongside GCSE bitesize**

For further reading: The institute of physics

Physics A-level: Helping me understand how the world works | Institute of Physics (iop.org)

School and college students | Institute of Physics (iop.org)

In order to confidently approach your A Level Physics studies there are certain fundamental concepts that you need to understand. Ensuring you have a secure foundation of GCSE knowledge to build upon will help to make the transition from GCSE to A level smoother and maximise your chances of success.

Threshold concept 1: Foundations of physics

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What is a physical quantity?	a property of an object or of a phenomenon that can be measured
What are the S.I. units of mass, length, and time?	kilogram (kg), metre (m), second (s)
What base quantities do the S.I. units A, K, and mol represent?	current, temperature, amount of substance
List the prefixes, their symbols and their multiplication factors from pico to tera (in order of increasing magnitude)	pico (p) 10^{-12}, nano (n) 10^{-9}, micro (μ) 10^{-6}, milli (m) 10^{-3}, centi (c) 10^{-2}, deci (d) 10^{-1}, kilo (k) 10^{3}, mega (M) 10^{6}, giga (G) 10^{9}, tera (T) 10^{12}
What is a scalar quantity?	a quantity that has magnitude (size) but *no* direction
What is a vector quantity?	a quantity that has magnitude (size) *and* direction
What are the equations to resolve a force, *F*, into two perpendicular components, F_x and F_y?	$F_x = F\cos\theta$ $F_y = F\sin\theta$
What is the difference between distance and displacement?	distance is a scalar quantity displacement is a vector quantity
What does the Greek capital letter Δ (delta) mean?	'change in'
What is the equation for average speed in algebraic form?	$v = \frac{\Delta s}{\Delta t}$
What is instantaneous speed?	the speed of an object over a very short period of time
What does the gradient of a displacement–time graph tell you?	velocity
How can you calculate acceleration and displacement from a velocity–time graph?	acceleration is the gradient displacement is the area under the graph
Write the equation for acceleration in algebraic form	$a = \frac{\Delta v}{\Delta t}$
What do the letters *suvat* stand for in the equations of motion?	*s* = displacement, *u* = initial velocity, *v* = final velocity, *a* = acceleration, *t* = time taken
Write the four *suvat* equations.	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{\frac{1}{2}(u+v)}{t}$
What does *free fall* mean?	when an object is accelerating under gravity with no other force acting on it
What is an atom made up of?	a positively charged nucleus containing protons and neutrons, surrounded by electrons

Define a *nucleon*	a proton or a neutron in the nucleus
What are the absolute charges of protons, neutrons, and electrons?	+ 1.60×10^{-19}, 0, and − 1.60×10^{-19} coulombs (C) respectively
What are the relative charges of protons, neutrons, and electrons?	1, 0, and − 1 respectively (charge relative to proton)
What is the mass, in kilograms, of a proton, a neutron, and an electron?	1.67×10^{-27}, 1.67×10^{-27}, and 9.11×10^{-31} kg respectively
What is the atomic number of an element?	the number of protons
Define an isotope	isotopes are atoms with the same number of protons and different numbers of neutrons
Write what *A*, *Z* and X stand for in isotope notation $({}^{A}_{Z}\mathrm{X})$	*A*: the number of nucleons (protons + neutrons) *Z*: the number of protons X: the chemical symbol
Name the force that holds nuclei together	strong nuclear force
What is the range of the strong nuclear force?	from 0.5 to 3−4 femtometres (fm)
Name the three kinds of radiation	alpha, beta, and gamma
What particle is released in alpha radiation?	an alpha particle, which comprises two protons and two neutrons
Write the symbol of an alpha particle	${}^{4}_{2}\alpha$
What particle is released in beta radiation?	a fast-moving electron (a beta particle)
Write the symbol for a beta particle	${}^{0}_{-1}\beta$
Define *gamma radiation*	electromagnetic radiation emitted by an unstable nucleus
What particles make up everything in the universe?	matter and antimatter
Name the antimatter particles for electrons, protons, neutrons, and neutrinos	positron, antiproton, antineutron, and antineutrino respectively
What happens when corresponding matter and antimatter particles meet?	they annihilate (destroy each other)
List the seven main parts of the electromagnetic spectrum from longest wavelength to shortest	radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays
Write the equation for calculating the velocity of electromagnetic radiation	Velocity (c)= frequency(f) x wavelength (λ)
Define a *photon*	a packet of electromagnetic waves
What is the speed of light?	3.00×10^{8} m s^{-1}
Write the equation for calculating photon energy	photon energy (*E*) = Planck constant (*h*) × frequency (*f*)
Name the four fundamental forces	gravity, electromagnetic, weak nuclear, strong nuclear

Threshold concept 2: Maths for physics

Units are defined so that, for example, every scientist who measures a mass in kilograms uses the same size for the kilogram and gets the same value for the mass. Scientific measurement depends on standard units – most are *Système International* (SI) units. Every measurement must give the unit to have any meaning. You should know the correct unit for physical quantities.

Base Units

Physical quantity	**Unit**	**Symbol**	**Physical quantity**	**Unit**	**Symbol**
length	metre	m	electric current	ampere	A
mass	kilogram	kg	temperature difference	Kelvin	K
time	second	s	amount of substance	mole	mol

Derived units
Example:

speed= distance travelled / time taken

If a car travels 2 metres in 2 seconds:

Speed = 2m / 2 s = 1m/s

This defines the SI unit of speed to be 1 metre per second (m/s), or 1 m s^{-1}

Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

3.62 25.4 271 0.0147 0.245 39 400

(notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^{8}

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:
590 (to 3.s.f.) or 5.90×10^{2}

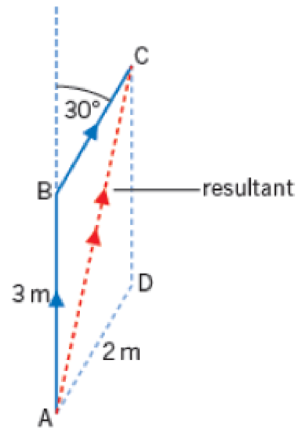
Drawing vectors

Vectors are shown on drawings by a straight arrow. The arrow starts from the point where the vector is acting and shows its direction. The length of the vector represents the magnitude. When you add vectors, for example two velocities or three forces, you must take the direction into account.

The combined effect of the vectors is called the resultant.

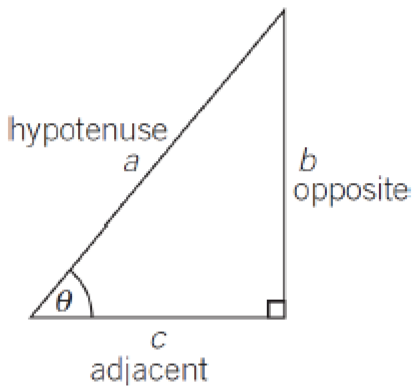
This diagram shows that walking 3 m from A to B and then turning through 30° and walking 2 m to C has the same effect as walking directly from A to C. AC is the resultant vector, denoted by the double arrowhead.

A careful drawing of a scale diagram allows us to measure these. Notice that if the vectors are combined by drawing them in the opposite order, AD and DC, these are the other two sides of the parallelogram and give the same resultant.



Calculating resultants

When two forces are acting at right angles, the resultant can be calculated using Pythagoras's theorem and the trig functions: sine, cosine, and tangent.
For a right-angled triangle as shown:



$h^2 = o^2 + a^2$ (Pythagoras)
$\sin \theta = o/h$
$\cos \theta = a/h$
$\tan \theta = o/a$
(soh-cah-toa)

.

Rearranging equations

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, if you want to calculate the resistance *R*, the equation:

potential difference (*V*) = current (*A*) × resistance (Ω) or $V = I\,R$

must be rearranged to make *R* the subject of the equation: R = V/I

When you are solving a problem:
• Write down the values you know and the ones you want to calculate.
• you can rearrange the equation first, and then substitute the values

or
• substitute the values and then rearrange the equation.

Threshold concept 2: worksheet

1. **Units:** Complete this table by filling in the missing units and symbols.

Physical quantity	**Equation used to derive unit**	**Unit**	**Symbol and name (if there is one)**
frequency	period^{-1}	s−1	Hz, hertz
volume	length^3		-
density	mass ÷ volume		-
acceleration	velocity ÷ time		-
force	mass × acceleration		
work and energy	force × distance		

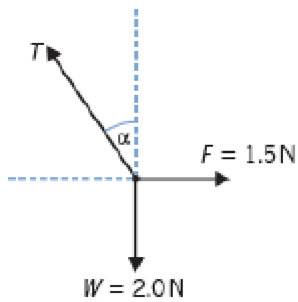
2. Give these measurements to 2 significant figures:
a 19.47 m
b 21.0 s
c 1.673×10^{-27} kg
d 5 s

3. Use the equation: Resistance= Potential difference / Current

to calculate the resistance of a circuit when the potential difference is 12 V and the current is 1.8 mA. Write your answer in kΩ to 3 s.f.

4. Two tractors are pulling a log across a field. Tractor 1 is pulling north with force 1 = 5 kN and tractor 2 is pulling east with force 2 = 12 kN. By scale drawing, determine the resultant force.

5. The diagram shows three forces in equilibrium.
Draw a triangle of forces to find *T* and *α*.



6. Find the resultant force for the following pairs of forces at right angles to each other:
a 3.0 N and 4.0 N
b 5.0 N and 12.0 N

7. Calculate the specific latent heat of fusion for water from this data:
4.03×10^4 J of energy melted 120 g of ice.

Use the equation:
thermal energy for a change in state (J) = mass (kg) × specific latent heat (J kg^{-1})

Give your answer in J kg^{-1} in standard form.

Threshold concept 3: Energy and Electricity

Energy review

Law of conservation of energy
Energy cannot be created or destroyed. It can only be transferred, stored or dissipated. In a closed system there can be energy transfers (where the energy has changed form) but there would be no net change in the total energy. In all system changes, energy is dissipated. We often describe this as wasted energy.

Kinetic energy
Kinetic energy is the amount of energy an object possesses when it is moving.

$$E_k = \frac{1}{2}mv^2$$

Where E_k is the energy (in joules), m is the mass (in kilograms) and v is the velocity (in metres per second.

Gravitational potential energy
This is the amount of energy an object has when it is above ground level

$$E_p = mgh$$

Where E_p is the energy (in joules), m is the mass (in kilograms), g is the gravitational field strength (in Newtons per kilogram) and h is the height (in metres)

Power
Power is defined as the rate at which energy is transferred or the rate at which work is done.

$$P = \frac{E}{t}$$

Where P is the power (in Watts), E is the energy (in joules) and t is the time (in seconds)

Elastic potential energy
This is the amount of energy stored in a stretched object.

$$E_e = \frac{1}{2}ke^2$$

Where E_e is the energy (in joules), k is the spring constant (in Newtons per metre and e is the extension (in metres)

Work done

This is the amount of energy transferred when applying a force to move an object a set distance

$$W = Fs$$

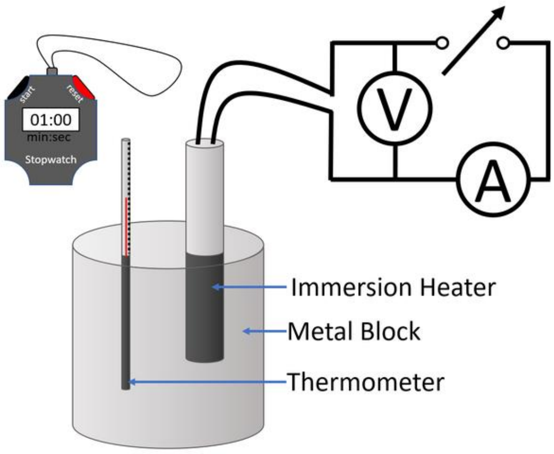
Where W is the work done (in joules), F is the force (in Newtons) and s is the displacement (in metres).

Specific heat capacity

The definition of specific heat capacity is: the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius. The equation specific heat capacity is:

$$\Delta E = mc\Delta\theta$$

Where ΔE is the change in energy (in joules), m is the mass (in kilograms), c is the specific heat capacity (in joules per kilogram ˚C) and Δθ is the change in temperature (in ˚C). Specific heat capacity has a core practical:



By supplying electricity to an immersion heater we can measure the temperature rise of the metal block. This will allow us to work out the specific heat capacity of the metal block.

Knowing the power applied and the time the heater is on for, we can work out the energy supplied.

We would use a top pan balance to find the mass of the metal block.

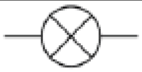
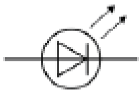
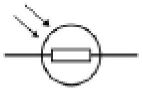
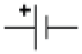
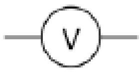
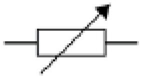
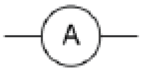
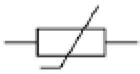
Efficiency

In industry we try to make processes as efficient as possible. This means reducing unwanted energy transfers. For example, we can use lubrication to reduce energy transfer due to friction, and thermal insulation to reduce energy transfer due to conduction. In buildings, the rate of cooling is affected by the thickness and thermal conductivity of its walls. The equation for efficiency is:

$$efficiency = \frac{useful\ energy\ output}{total\ energy\ input}$$

Electricity review

Circuit symbols

 switch (open)	 lamp	 LED
 switch (closed)	 fuse	 LDR
 cell	 voltmeter	 variable resistor
 battery	 ammeter	 thermistor
 diode	 resistor	

Rules for circuits

For components connected in series:

- There is the same current through each component
- The total p.d of the power supply is shared between the components.
- The total p.d of cells in series is the sum of the individual cells.

For components connected in parallel:

- The p.d across each component is the same
- The total current through the whole circuit is the sum of the currents through the separate components.

Equations:

1. Charge flow = current x time $Q = I\,t$
2. potential difference = current x resistance $V = I\,R$
3. Total resistance in series = Resistance 1 + resistance 2 $R_{total} = R_1 + R_2$
4. Power = potential difference x current $P = V\,I$
5. Power = $(\text{current})^2$ x resistance $P = I^2\,R$
6. Energy transferred = power x time $E = P \times t$
7. Energy transferred = charge flow x potential difference $E = Q\,V$
8. The total resistance of two resistors in parallel is less than the resistance of the smallest individual resistor.

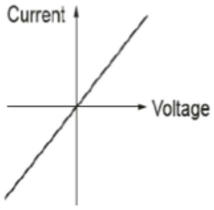
Definitions:

Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge. Potential difference is the energy supplied to an electric current by the power supply.

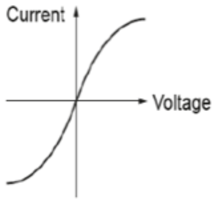
Resistance is an opposition to the flow of electricity.

Ohm's Law: The current through an Ohmic conductor (at a constant temperature) is directly proportional to the potential difference across the resistor.
National grid is the system of cables and transformers linking power stations to consumers.

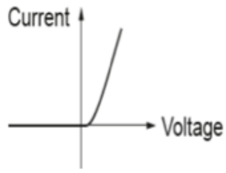
Ohmic and non-Ohmic conductors:



Fixed Resistor (Ohmic conductor)



Filament lamp (non-Ohmic conductor)



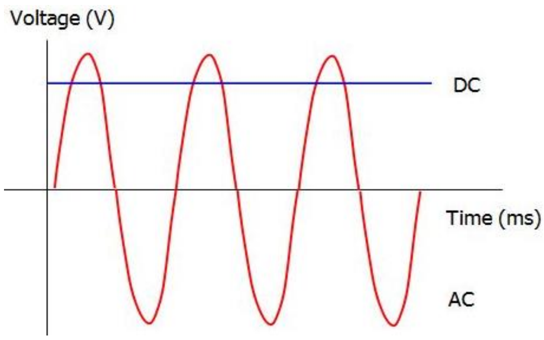
Diode (non-Ohmic conductor

Sensors:
Thermistors: The resistance of a **thermistor decreases** as the temperature **increases.**
LDR: The resistance of an **LDR decreases** as light intensity **increases.**

AC/DC

Mains electricity is called alternating current or an ac supply. An alternating current constantly changes direction, whereas a direct current (or dc supply) remains at the same level.

Mains electricity: 230V, 50Hz



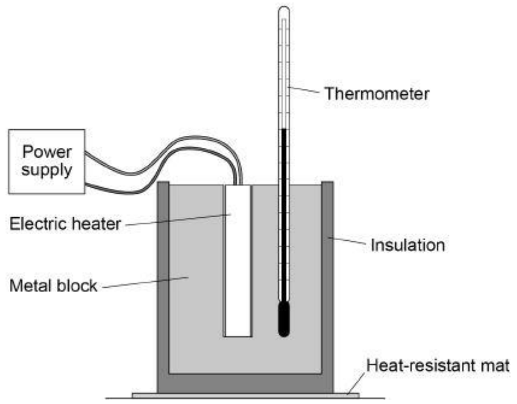
Threshold concept 3: Worksheet

1. A student investigated how the temperature of a metal block changed with time.

   An electric heater was used to increase the temperature of the block.

   The heater was placed in a hole drilled in the block as shown in **Figure 1**.

Figure 1



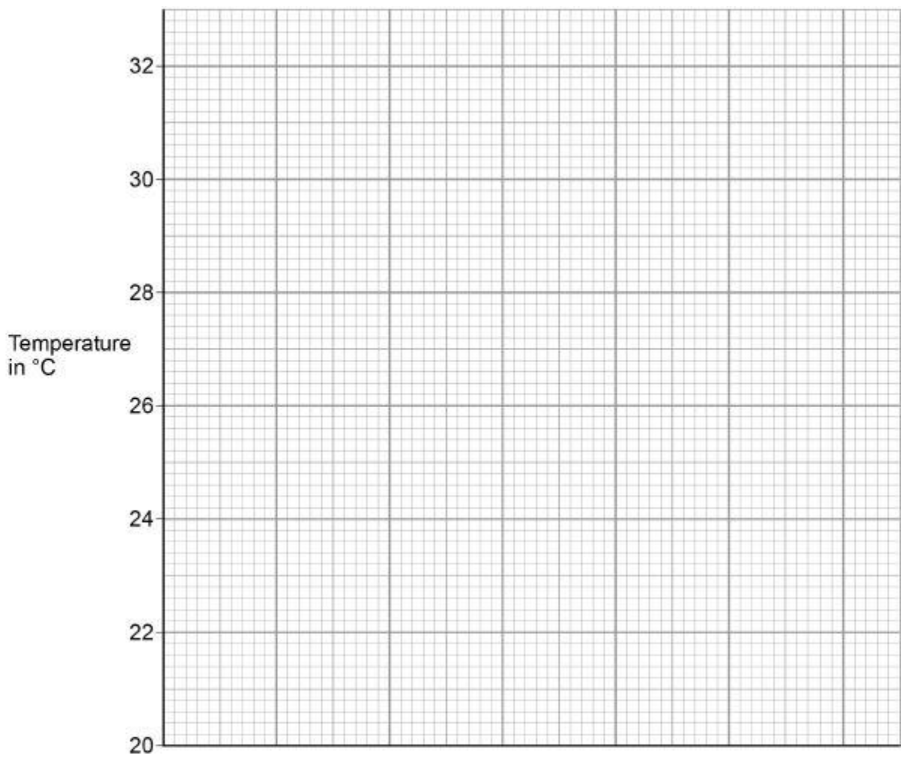
The student measured the temperature of the metal block every 60 seconds. The table below shows the student's results.

Time in s	Temperature in °C
0	20.0
60	24.5
120	29.0
180	31.0
240	31.5

(a) Complete the graph of the data from the table above on the graph below.

- Choose a suitable scale for the x-axis.
- Label the x-axis.
- Plot the student's results.
- Draw a line of best fit.

Figure 2



(4)

(b) The rate of change of temperature of the block is given by the gradient of the graph.

Determine the gradient of the graph over the first 60 seconds.

____

____

____

____

Gradient = ________________________

(2)

(c) The metal block had a mass of 1.50 kg

The specific heat capacity of the metal was 900 J/kg °C

Calculate the change in thermal energy of the metal during 240 seconds.

Use the Physics Equations Sheet.

Give your answer in kilojoules.

____

____

____

____

____

____

____

Change in thermal energy = ____________________ kJ

(4)

(d) Another student repeated the investigation.

Give **two** variables this student would need to control to be able to compare their results with the results in the table above.

1.

____

2.

____

(2)

(Total 12 marks)

2. A light dependent resistor (LDR) is connected in a circuit.

(a) Draw the circuit symbol for an LDR.

(1)

(b) A student investigated the relationship between current and potential difference for an LDR.

How should the student have connected the ammeter and voltmeter in the circuit?

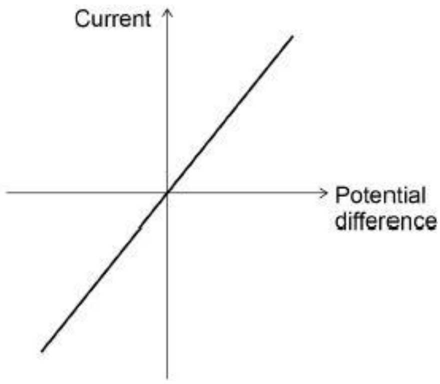
Tick **one** box.

Ammeter	**Voltmeter**	
in parallel with LDR	in parallel with LDR	☐
in parallel with LDR	in series with LDR	☐
in series with LDR	in parallel with LDR	☐
in series with LDR	in series with LDR	☐

(1)

The diagram below shows a sketch graph of the student's results.

The LDR was in a constant bright light.



(c) The student concluded that the current in the LDR is inversely proportional to the potential difference across the LDR.

Explain why the student's conclusion is incorrect.

(2)

(d) The student repeated the investigation with the LDR in constant dark conditions.

Sketch on the diagram above the graph for the LDR in constant dark conditions.

(2)

The LDR was placed near a light source.

The following results were recorded:

potential difference = 5.50 V

current = 12.5 mA

(e) Write down the equation that links current, potential difference and resistance.

(1)

(f) Calculate the resistance of the LDR.

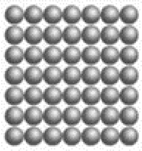
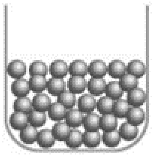
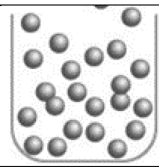
Resistance = ______________ Ω **(4)**

(Total 11 marks)

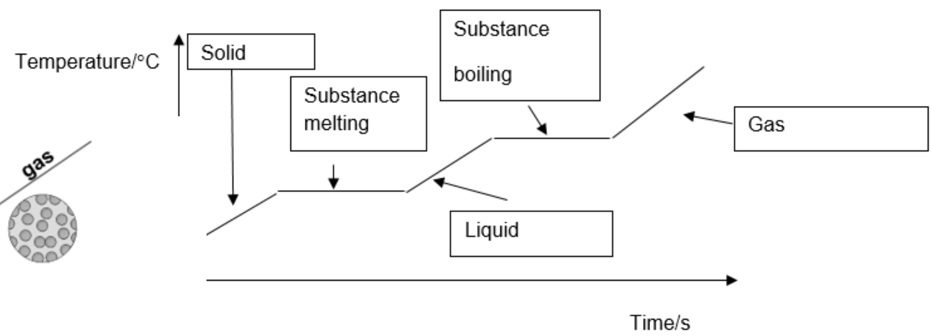
Threshold concept 4: Particle model and Radioactivity

The particle model review

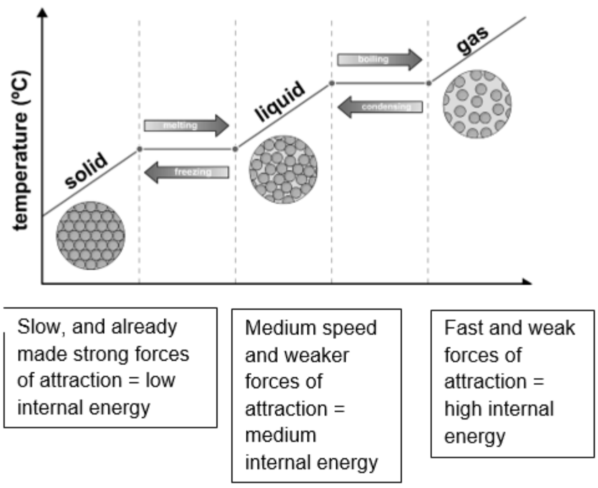
Solids, liquids and gases: the particle model

Solid	*Liquid*	*Gas*
• Atoms in fixed positions • Atoms arranged in rows/columns • Atoms vibrate • Fixed shape	• Atoms free to flow • Atoms have random arrangement –all touching • Takes shape of container	• Atoms free to move • Atoms have random arrangement – many gaps between • Fills the container
		

Floating and sinking
An object will sink in water if its density is greater than that of water. An object will float if its density is equal to or less than water.



Changes of state



Internal energy
Energy is stored inside a system by the particles that make up the system (atoms and molecules). This is called internal energy. The total internal energy is found by adding together all the potential energies and all the kinetic energies of the particles.

Substances can change state (melt, freeze, boil, evaporate, condense or sublimate), when they do mass is conserved. The same particles still exist. Changes of state are a physical change - the material has the same properties once the change is reversed.

During a change of state, the temperature will not rise until all of the substance has changed state.
A vapour is a gas given off by a liquid. Evaporation can happen at any temperature in the liquid state and is when more energetic particles leave the surface of the liquid. Boiling is when a liquid will have vapourisation occurring through the entire liquid (not just on the surface) at the liquid's boiling point. A few

substances turn straight from a solid to a gas with no liquid phase. This is sublimation. **Latent heat is the amount of energy required to change the state of one kilogram of the substance with no change in temperature.**

Specific heat capacity is the amount of energy required to raise the temperature of 1 kg of a substance by 1˚C.

Equations

Density = Mass / volume	$\rho = m \div v$
Energy for a change of state = mass × specific latent heat	$E = mL$
Pressure x volume = constant	$p\,V$ = constant
Energy = mass x specific heat capacity x temperature change	$E = mc\Delta\theta$

Temperature and pressure

For a constant volume of a gas, if the temperature is increased the pressure will increase. Temperature is proportional to pressure (for a constant volume of gas). P x V is a constant value.

Molecules in a gas are in constant, random motion.
The higher the temperature of a gas the higher the average kinetic energy of the molecules.
Increased temperature: particles move faster → more collisions
Increased pressure: particles are closer together→ more collisions

Work done means the same thing as energy transferred,
Doing work on a gas increases its internal energy, this may cause an increase in temperature (or a change of state).

Radioactivity review

The structure of an atom

The basic structure of an atom is a positively charged nucleus composed of protons and neutrons, surrounded by negatively charged electrons. Most of the mass is concentrated in the nucleus, which is less than 1/10000 of the radius of the atom. The electrons are arranged at different distances from the nucleus and these distances might change if the electrons absorb or emit electromagnetic radiation. Isotopes are atoms with the same number of protons but a different number of neutrons.

The development of the model of the atom

The discovery of the electron led to the change in theory of the atom from 'tiny indivisible spheres' to the plum pudding model. The plum pudding model suggested that the atom is a ball of positive charge with negative electrons embedded in it. The alpha scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. The nuclear model replaced the plum pudding model. Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles with the same amount of positive charge. These were called protons. James Chadwick later provided the evidence to show the existence of neutrons within the nucleus.

Unstable nuclei
Some atomic nuclei are unstable. The nucleus gives out radiation as it changes to become more stable. This is a random process called radioactive decay. Activity is the rate at which a source of unstable nuclei decays and it is measured in bequerel (Bq). Count rate is the number of decays recorded each second by a detector (such as a geiger muller tube).

The three types of radiation
The nuclear radiation emitted may be:

Type of radiation	Penetrating power	Range in air	Ionising ability
Alpha (α) (two neutrons and two protons)	low	A few cms	High
Beta (β) (a high speed electron)	medium	A few metres	Medium
Gamma (γ) (electromagnetic radiation)	high	kilometres	Low

Decay equations

Alpha decay causes both the mass and charge of the nucleus to decrease. As the nucleus is losing 2 protons and 2 neutrons, the mass number decreases by 4 and the atomic number decreases by 2. For example:

$$^{219}_{86}\text{radon} \longrightarrow ^{215}_{84}\text{polonium} + ^{4}_{2}\text{He}$$

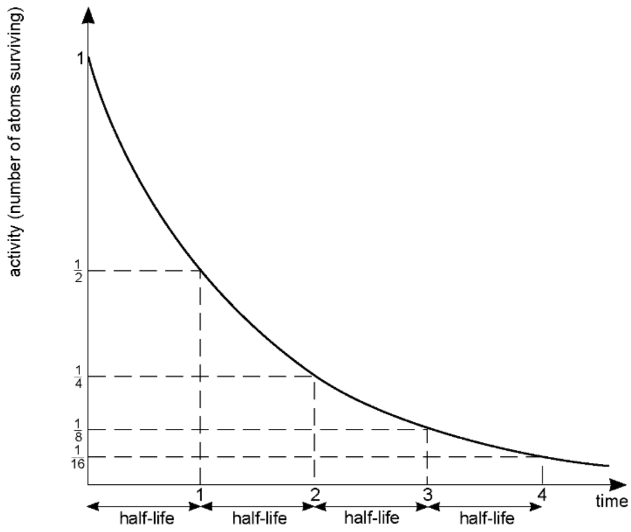
Beta decay does not cause the mass of the nucleus to change, but does cause the charge of the nucleus to increase. As a neutron is changing into a proton and emitting an electron, the mass number stays the same, but the atomic number increases by 1. For example:

$$^{14}_{6}\text{carbon} \longrightarrow ^{14}_{7}\text{nitrogen} + ^{0}_{-1}\text{e}$$

The emission of a gamma ray does not cause the mass or the charge of the nucleus to change.

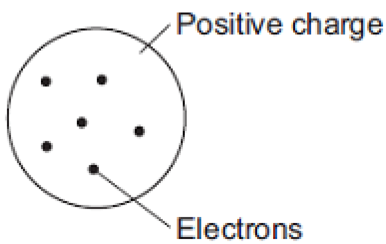
Half life

Radioactive decay is random. The half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve. A half-life graph has an exponential shape. After 1 half-life the count rate of the sample would have been reduced to a half, after 2 half-lives it would be a quarter and so on.

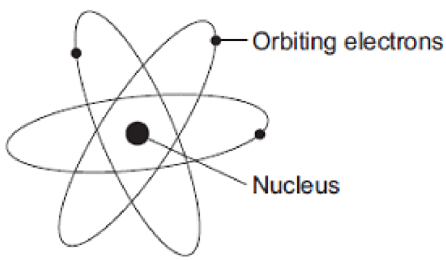


Threshold concept 4: Worksheet

1. In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.



Describe the differences between the two models of the atom.

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(Total 4 marks)

2. The Chernobyl disaster was a nuclear accident that happened in 1986. Radioactive

isotopes were released into the environment. The radioactive isotopes emitted alpha, beta and gamma radiation.

(a) What is an alpha particle?

Tick **one** box.

2 charged particles and 2 neutral particles. ☐

2 charged particles and 4 neutral particles. ☐

4 charged particles and 2 neutral particles. ☐

4 charged particles and 4 neutral particles. ☐

(1)

(b) Which statement about beta radiation is true? Tick **one** box.

It is the fastest moving type of radiation. ☐

It is the type of radiation with a negative charge. ☐

It is the type of radiation with the greatest mass. ☐

It is the type of radiation with the greatest range in air. ☐

(1)

(c) Which statement about gamma radiation is true?

Tick **one** box. (1)

It is a low frequency electromagnetic wave. ☐

It causes the charge of the nucleus to change. ☐

It causes the mass of the nucleus to change. ☐

It has a very long range in air. ☐

The table below shows the half-lives of two of the radioactive isotopes that contaminated the environment.

Isotope	**Half-life**
Caesium-137	30 years
Iodine-131	8 days

(d) A soil sample was taken from the area around Chernobyl in 1986

The soil sample was contaminated with equal amounts of caesium-137 and iodine-131

Explain how the risk linked to each isotope has changed between 1986 and 2018

Both isotopes emit the same type of radiation.

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(4)

(e) Determine the year when the activity of the caesium–137 in the soil sample will be 1/32 of its original value.

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Year = ___________________ **(3)** **(Total 10 marks)**

Threshold concept 5: Waves and Electromagnetism

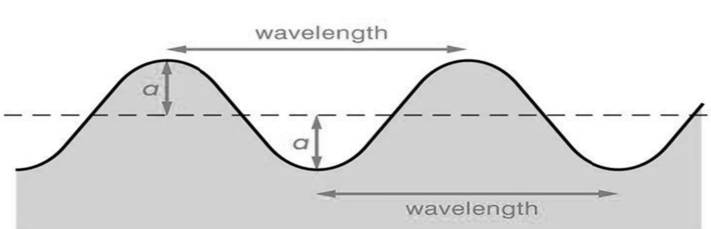
Waves review

Transverse waves

In a transverse wave the oscillations are at right angles (perpendicular) to the direction of travel of the wave. Examples of transverse waves include light, water waves, earthquake S waves, vibrations of a string etc.

Longitudinal waves

The oscillations are in the same direction (parallel) as the direction of travel of the wave. Examples of longitudinal waves include sound and earthquake P waves.



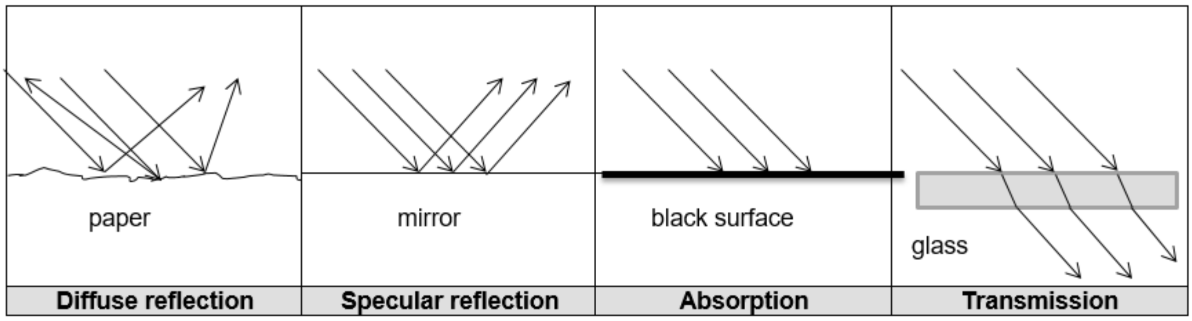
Wavelength: distance from a point on one wave to the equivalent point on the adjacent wave.
Amplitude: maximum displacement of a point on a wave away from its undisturbed position.

Frequency: the number of waves passing a point each second.

Equations

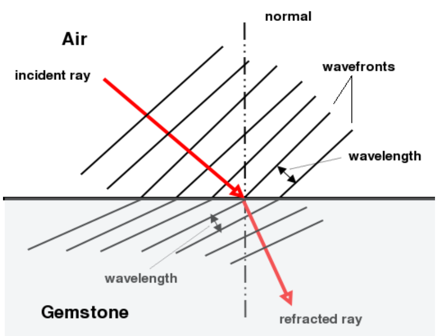
period = 1 ÷ frequency	$T = 1 \div f$
wave speed = frequency x wavelength	$v = f\lambda$

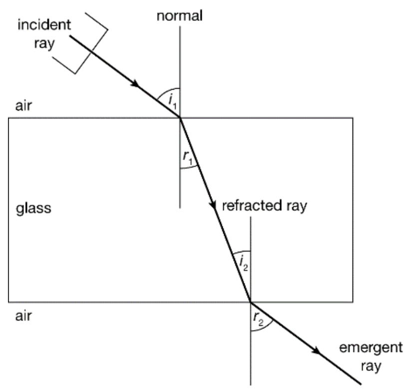
Waves at a boundary



Refraction

Electromagnetic waves move more slowly in denser media. Light moves more slowly a glass than air. When a light beam passes from the air into the glass, one side of the beam is slowed before the other side. This makes the beam bend. This is refraction.





EM spectrum

Long wavelength → Short wavelength

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

Low frequency → High frequency

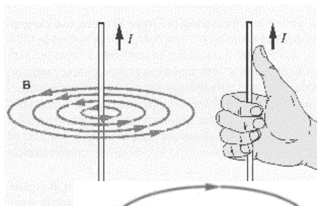
All electromagnetic waves travel at the same speed in a vacuum (3×10^{8} ms^{-1}).

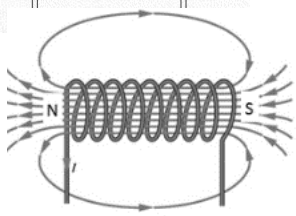
Sound
Sound waves are caused by vibrations and need a medium through which to travel. Sound waves are longitudinal. Range of human hearing: 20Hz to 20,000Hz.

Electromagnetism review

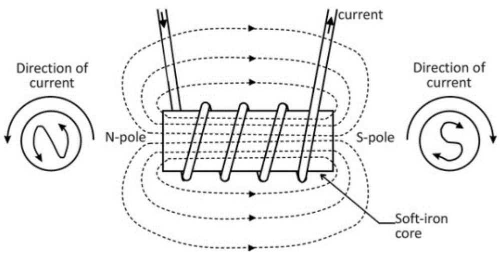
Magnetism
There are 3 magnetic materials: Iron, cobalt and nickel. These elements (or materials containing these elements) are attracted to the poles of a magnet. Magnetic field lines run from the north pole to the south pole. A permanent magnet produces its own magnetic field. An induced magnet is a material that becomes magnetised when placed in a magnetic field. An induced magnet will lose its magnetism quickly when removed from a magnetic field. The Earth has its own magnetic field. A compass needle is a small magnet that will point to the north if left to move freely.

Electromagnets
A current carrying wire generates its own magnetic field.
A solenoid is a coil of wire. This has a stronger magnetic field.
Inside the coil it is strong and uniform.
Outside it resembles a bar magnet.
To increase the strength, increase the current, the number of turns of wire and add an iron core. The poles depend on the direction of current flow.

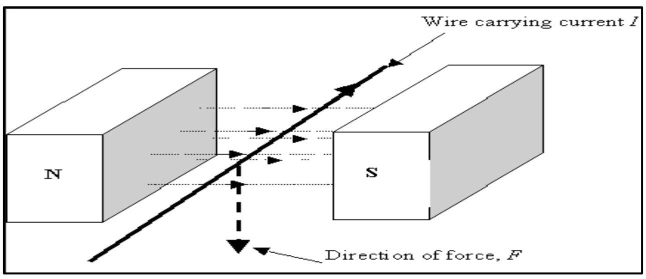




Solenoid

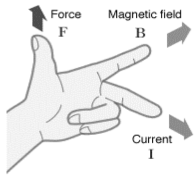


The Motor Effect
A current carrying wire placed in a magnetic field experiences a force.



To find the size of the force

Force = magnetic flux density x current x length F = BIL
Where force, F, in Newtons, N; magnetic flux density, B, in tesla, T; current, I, in amperes, A; length, L, in metres, m.



Threshold concept 5: Worksheet

1. Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

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(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

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____**(4)**

(Total 7 marks)

2. When a conductor carrying a current is placed in a magnetic field a force is exerted on the conductor.

This is called the motor effect.

(a) Describe how the direction of the force can be determined using Fleming's Left Hand Rule.

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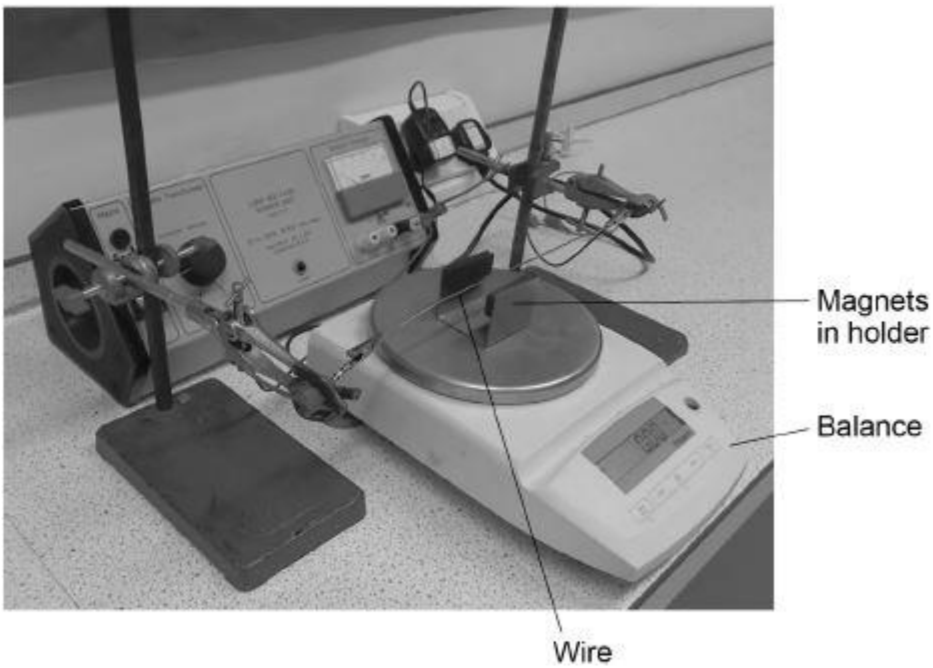
(4)

The photograph below shows apparatus to demonstrate the motor effect.



The piece of wire is fixed so that it cannot move.

This is the method used.

1. Place the pair of magnets in their holder on the balance.
2. Set the reading on the balance to zero.
3. Pass a current through the wire.

4. Record the new reading on the balance.

(b) When there is a current in the wire, the reading on the balance increases.

Explain in terms of forces why the reading increases.

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(3)

(c) In one experiment, the teacher determined that the force on the wire was 2.14 mN

The current in the wire was 0.32 A

The length of wire within the magnetic field was 0.048 m

Calculate the magnetic flux density between the two magnets.

Use the Physics Equations Sheet. (F = BIL)

Give your answer to 2 significant figures.

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Magnetic flux density = ________________ T

(4)

(Total 11 marks)

Threshold concept 6: Forces and motion

Review

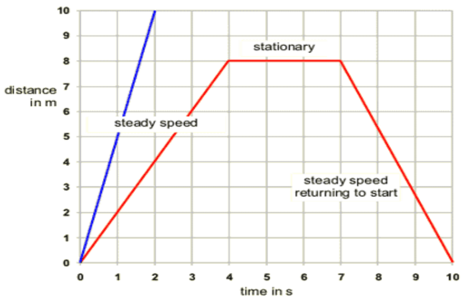
Distance and displacement.
Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity. Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line. Displacement is a vector quantity.

Speed
Speed does not involve direction. Speed is a scalar quantity. The speed of a moving object is rarely constant. For an object moving at constant speed the distance travelled in a specific time can be calculated using the equation: **distance travelled = speed× time** $s = v\,t$

distance, s, in metres, m, speed, v, in metres per second, m/s, time, t, in seconds, s

Velocity
The velocity of an object is its speed in a given direction. Velocity is a vector quantity. As velocity is speed in a given direction if the direction changes, velocity changes. This means that motion in a circle involves constant speed but changing velocity.

Distance-time graphs
The speed of an object can be calculated from the gradient of its distance–time graph.
If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.



The horizontal line represents a stationary object.

The straight gradients represent a steady speed.

The steeper gradient represents a faster moving object.

Acceleration
When an object speeds up the acceleration is **positive**. When an object slows down the acceleration is **negative.** A negative acceleration is called **deceleration**.
The average acceleration of an object can be calculated using the equation:

$$\textbf{Acceleration} = \frac{\textbf{change in velocity}}{\textbf{time taken}} \quad \text{or} \quad a = \frac{\Delta v}{t}$$

acceleration, a, in metres per second squared, m/s^2, change in velocity, Δv, in metres per second, m/s, time, t, in seconds, s.

The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph. Acceleration is the gradient of a velocity-time graph.

The following equation applies to uniform acceleration: $\boldsymbol{v^2 - u^2 = 2\,a\,s}$

(final velocity)^2 – (initial velocity)^2 = 2 x acceleration x displacement.

final velocity, *v*, in metres per second, m/s, initial velocity, *u*, in metres per second, m/s acceleration, *a*, in metres per second squared, m/s^2, distance, *s*, in metres, m

Newton's First Law
If the resultant force acting on an object is zero and the object is stationary, the object remains stationary. If the resultant force acting on an object is zero and the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.

Newton's Second Law
The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.

This can be represented by the following equation:
resultant force = mass × acceleration $\boldsymbol{F = m\,a}$

force, *F*, in newtons, N, mass, *m*, in kilograms, kg, acceleration, *a*, in metres per second squared, m/s^2

Newton's Third Law
Whenever two objects interact, the forces they exert on each other are equal and opposite.

Mass and weight
The mass of an object is the **amount of matter** it contains. The Earth's gravitational field strength is about 9.8N/kg. The force of the Earth's gravity on you is called your **weight**. **Weight = Mass x Gravitational Field Strength, W= mg**

Weight, W, in Newtons, N, mass, m, in kilograms, kg, gravitational field strength, g, in Newtons per kilogram, N/kg.

Terminal velocity
When an object starts to fall the force of gravity is much greater than the drag force (friction). So the object will **accelerate**. As speed increases, *friction builds up*. So the acceleration will gradually decrease until frictional **force is equal to the accelerating force**. The *resultant force will be zero* (travelling at the same speed). This is the point of **terminal velocity**.

Momentum
Momentum is a property of moving objects. Momentum is defined by the equation: **momentum = mass × velocity** $\boldsymbol{p = m\,v}$
momentum, *p*, in kilograms metre per second, kg m/s, mass, *m*, in kilograms, kg, velocity, *v*, in metres per second, m/s.

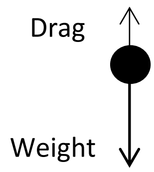
- The faster an object is moving the more momentum it has.
- An object with more mass will have more momentum than one with less mass moving at the same speed.

Conservation of momentum
A closed system is something that is not affected by external forces. In a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum. Momentum is conserved in collisions and explosions.
(Mass of A x velocity of A) - (mass of B x velocity of B) = 0

Scalar and vector quantities
A scalar is a quantity which has magnitude (size) only. A vector quantity is a quantity which has magnitude and an associated direction.

Addition of vectors
Adding scalars is just adding numbers together. Adding vectors, however, has to take account of the direction. When adding two or more vectors acting from the same point they add up to give a resultant which is the overall effect of the two or more vectors.

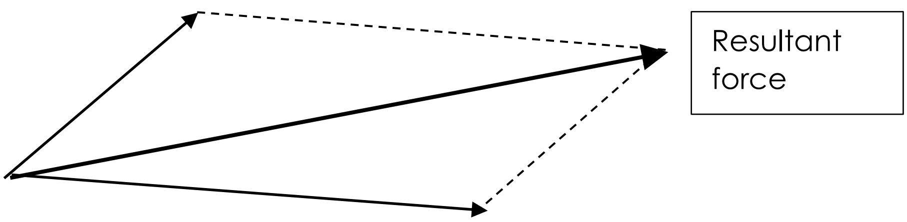
Free body diagrams
Show the forces acting on an object. The direction of the arrow shows the direction of the force. The size of the arrow represents the size of the force. In the example opposite, the weight is larger than the drag.



Resultant forces
The free body diagram shows two forces acting on an object. The forces are acting in opposite directions and in this example the weight is greater than the drag force. Adding both these forces together would result in a single force acting downwards. This is called the resultant force. The resultant force, is the single force that has the same effect as all the individual forces acting on the object.

When the forces are parallel to each other the resultant force is either the addition or subtraction of the individual forces. Forces which are at an angle need to be resolved into components. A single force can be resolved into two components acting at right angles to each other. The components added together have the same effect as a single force.

Parallelogram of forces
We can use vector addition to add two forces to determine the resultant force. A method called the parallelogram of forces can be used to construct scale diagrams to show the resultant force.

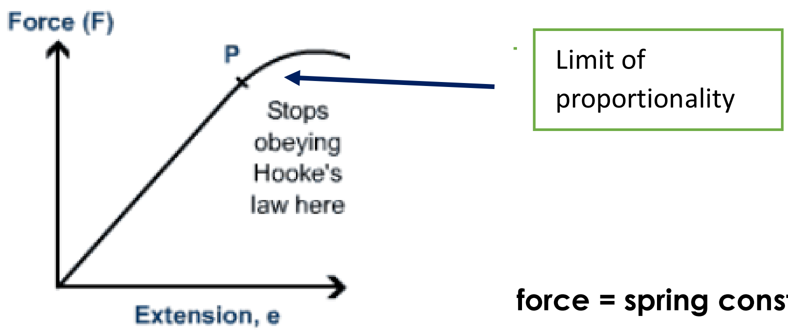


Work done and energy transfer
Work is the energy transferred whenever a force moves an object through a distance. Work done on an object can be calculated using the equation:

Work done = force x displacement (moved along the line of action of the force)
$W = F s$

Work done, W, in joules, J; force, F, in Newtons, N; distance, s in metres, m.
s is the symbol for displacement, which is a vector quantity, as it is distance moved in a direction.

The relationship between force and extension
Hooke's law: Force is proportional to extension provided the elastic limit has not been exceeded.



force = spring constant x extension

$F = k e$

Where force, F, in Newtons, N; spring constant, k, in Newtons per metre, N/m; extension, e, in metres, m.

Work done on a spring
A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal. The work done on a spring can be calculated from the following equation. **elastic potential energy = 0.5 x spring constant x (extension)^2 $E_e = \frac{1}{2} k e^2$**

Moments and levers

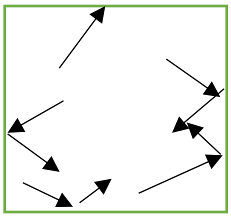
The turning effect of a force is called a moment. It depends on the distance the force is applied from the pivot and the size of the force. The moment of a force is defined by the equation: **Moment of a force = force x distance $M = F d$**

moment of a force, M, in newton-metres, Nm; force, F in newtons, N; distance, d, is the perpendicular distance from the pivot to the line of action of the force, in metres, m.

If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot. (Note the pivot point does not have to be between each force).

Pressure in a fluid

The particles in a fluid are in constant motion. These particles collide with the surface of the container (as well as each other). On average there are the same number of collisions from one side as the other, therefore we can say the force of the collisions acts at the normal (right angles) to the surface.



The pressure at the surface of a fluid can be calculated using the equation:

$$\text{pressure} = \frac{\text{force normal to a surface}}{\text{area of that surface}} \qquad p = \frac{F}{A}$$

Pressure, p in pascals, Pa; force, F, in newtons, N; area, A, in metres squared, m^2.

Pressure will increase in a liquid as the depth increases. The pressure due to a column of liquid can be calculated using the equation:

Pressure = height of the column x density of the liquid x gravitational field strength.
P = h ρ g

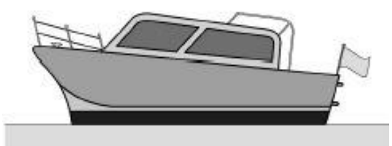
pressure, p, in pascals, Pa; height of the column, h, in metres, m; density, ρ, in kilograms per metre cubed, kg/m^3.

The pressure on the bottom of an object submerged in a fluid is greater than the pressure at the top of the object. This creates a resultant force upwards. This force is called the **upthrust**.

Threshold concept 6: Worksheet

Figure 1 shows a boat floating on the sea. The boat is stationary.

Figure 1



(a) **Figure 2** shows part of the free body diagram for the boat.

Complete the free body diagram for the boat. **Figure 2**

(2)

(b) Calculate the mass of the boat.

Use the information given in **Figure 2**.

gravitational field strength = 9.8 N/kg

Give your answer to **two** significant figures.

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Mass = ______________________ kg

(4)

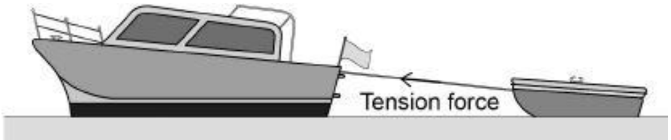
(c) When the boat propeller pushes water backwards, the boat moves forwards.
The force on the water causes an equal and opposite force to act on the boat.

Which law is this an example of?

____**(1)**

d) **Figure 3** shows the boat towing a small dinghy.

Figure 3



The tension force in the tow rope causes a horizontal force forwards and a vertical force upwards on the dinghy.

horizontal force forwards = 150 N
vertical force upwards = 50 N

Figure 4 shows a grid. Draw a vector diagram to determine the magnitude of the tension force in the tow rope and the direction of the force this causes on the dinghy.

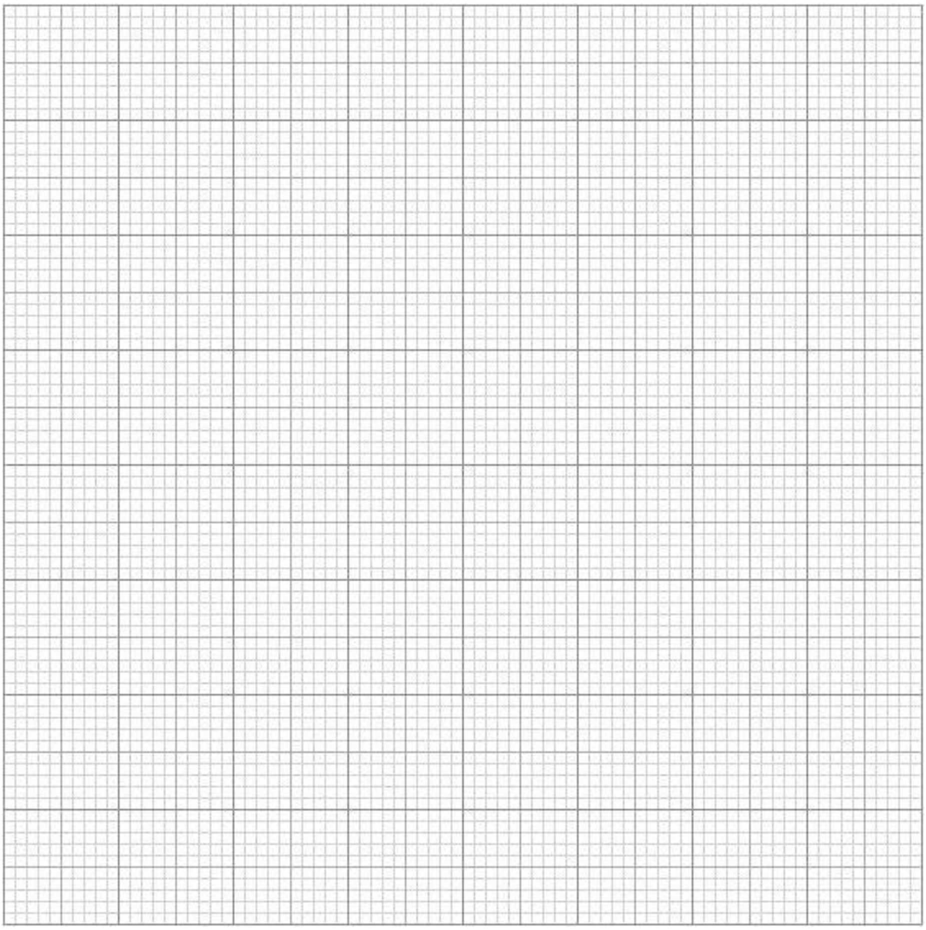


Figure 4

Magnitude of the tension force in the tow rope = ____________________ N

Direction of the force on the dinghy caused by the tension force in the tow rope = ______________________

(4)

(Total 11 marks)