



Aitchison College Academic Resources.

IGCSE PHYSICS (0625) RESOURCES

This document includes complete notes of each unit with unsolved and solved past paper questions. Don't forget to go through it and we hope this document will help you preparing for your exams.
Best of Luck!



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Paper Pattern:

Paper 2: Multiple Choice (Extended)

45 minutes

40 marks

40 compulsory multiple-choice items of the four-choice type

This paper tests assessment objectives AO1 and AO2

Paper 6: Alternative to Practical

1 hour

40 marks

All items are compulsory

This paper tests assessment objective AO3

Candidates will not be required to do experiments as part of this test

Externally assessed

Paper 4: Theory (Extended)

1 hour 15 minutes

80 marks

Compulsory short-answer and structured questions

This paper tests assessment objectives AO1 and AO2

This paper assesses grades A* to G

Externally assessed

AND

Specimen Papers:

[Specimen Paper 2](#)

[Specimen Paper 4](#)

[Specimen Paper 6](#)



Unit 1.1: Physical Quantities and Measurements

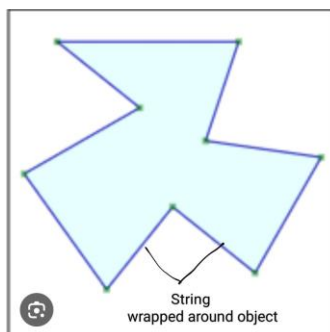
Overview: In physics, it is always important to think critically about the measurements one makes and the method used to make these measurements as small inaccuracies add up to form large errors or uncertainties. In this Chapter, we will be learning the different physical quantities, their units, and how to measure them. We will also be learning about scalars, vectors and how to find the resultant of two vectors.

Measuring length

A physical quantity is a property of a material or system that can be quantified by measurement. Among these physical quantities are length and time. The easiest way to measure length is to use a meter rule, or a ruler. For a regular object such as a cube, the ruler can be used to directly measure it.



Irregular objects like a twisted metal pipe cannot be measured directly, as the length measured would not be equivalent to the actual length of the pipe if it was straightened out.





For these, a thread can be used to trace the outline of the object by placing it close to the object and unravelling it till the object has been outlined. The points where the object's outline started and ended should be marked. Then the thread can be straightened out and a ruler can be used to measure its length.

The thread method can also be used to measure the diameter of a sphere by wrapping the thread around the sphere and measuring the length of the straightened thread.

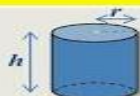
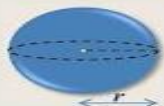
The SI (Standard International) unit of length is metres (m).

Measuring Volume

An object's volume is the space it occupies; It is measured in cubic metres(m^3).

For regular objects, volume can simply be calculated by using formulas.

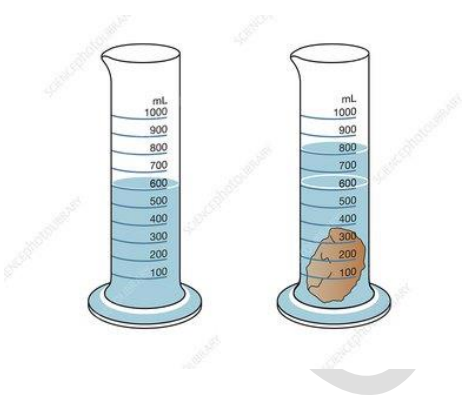
For irregular objects, however, measurements cannot be taken precisely so we use the finding volume by displacement method.

SURFACE AREA & VOLUME OF 3D SHAPES		
CUBE	CUBOID	CYLINDER
 SURFACE AREA TOTAL $A = 6l^2$ SIDES $A = 4l^2$ VOLUME $V = l^3$	 SURFACE AREA TOTAL $A = 2(ab + bc + ac)$ SIDES $A = 2(ab + 2ac)$ VOLUME $V = abc$	 SURFACE AREA TOTAL $A = 2\pi r(r + h)$ CURVED $A = 2\pi rh$ VOLUME $V = \pi r^2 h$
CONE	SPHERE	HEMISPHERE
 SURFACE AREA TOTAL $A = \pi r^2 + \pi rl$ CURVED $A = \pi rl$ VOLUME $V = \frac{1}{3} \pi r^2 h$	 SURFACE AREA $A = 4\pi r^2$ VOLUME $V = \frac{4}{3} \pi r^3$	 SURFACE AREA TOTAL $A = 3\pi r^2$ CURVED $A = 2\pi r^2$ VOLUME $V = \frac{2}{3} \pi r^3$



A measuring cylinder is filled with some volume of water and then the irregular object is immersed in it. The change in the level of water indicates the volume of the irregular object.

Look at the measuring cylinder horizontally and read from the bottom of the meniscus to avoid parallax error.



Measuring time

Time is measured in seconds (s) and we use digital timers or clocks to measure it.

Analogue clocks - such as the ones used to tell the time - can be used in labs to measure time to no better than the nearest second and are usually suitable for measuring larger intervals of time.

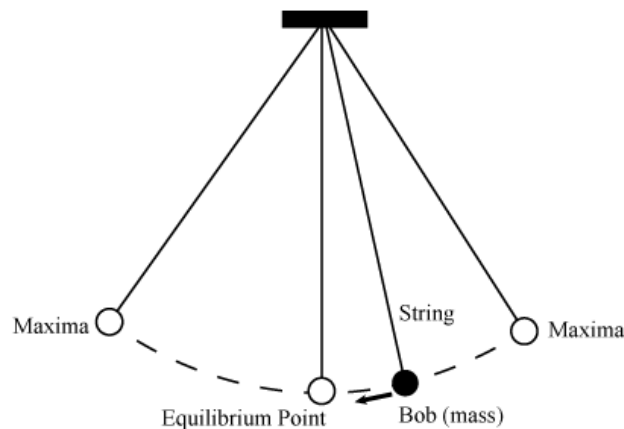
Digital timers such as stopwatches, on the other hand, give a direct reading of time in numerals and are precise to at least one-hundredth of a second. For even better precision, automated light gates may be used.

Counteracting Errors

When measuring any physical quantity that may be very tiny, it is likely to have a lot of errors. To reduce these errors it is best to take a large number of measurements and take the average. For example, when measuring the thickness of a sheet of paper, instead of trying to measure the thickness of one or two sheets, it is better to measure the total thickness of about 200 stacked sheets and then divide the answer by 200 to find the average thickness of one sheet.



The period of a pendulum is the time taken for one full swing of the pendulum bob.



To find the period more accurately, it is better to time at least 10 full swings of the pendulum and then divide by 10 (or the number of swings you have timed) to find the time taken for one full swing to occur. This minimises human reaction error, since it is a smaller part of the time recorded as a whole.

Scalars and Vectors

A scalar quantity is a physical quantity that has only magnitude and no direction. Examples include time, mass, energy, distance, speed and temperature.

A vector quantity is a physical quantity that has both magnitude and direction. This means that vector quantities can also be represented by an arrow pointing in the direction of the quantity.



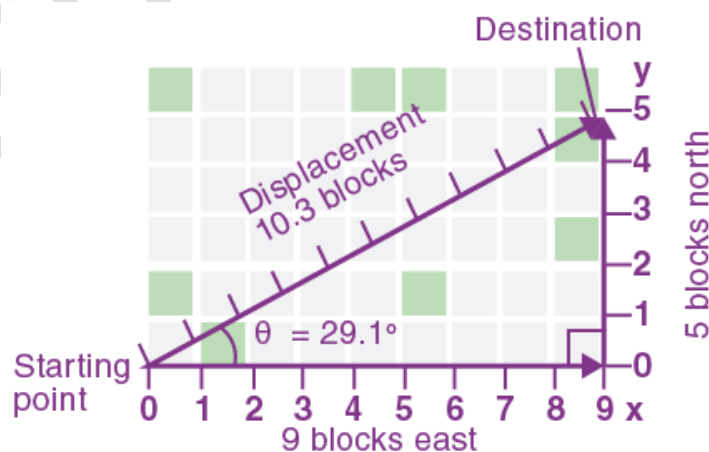
Some examples of vector quantities include force, weight, acceleration, displacement, velocity, momentum, electric field strength and gravitational field strength (g).

When given two or more vectors, it is possible to form a resultant vector combining their magnitudes and directions for simplification (only forces and velocity vectors at right angles required for IGCSE).

Calculating Resultant Vectors

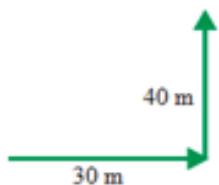
Calculating resultant vectors can either be done graphically or using calculation.

In the graphical method, you will need to draw a scale diagram. Use a suitable scale (e.g. $1\text{ cm} = 1.0\text{N}$) and draw the given vectors. The vector in the vertical direction must be drawn where the vector with the horizontal direction ends. Join the head of the first vector to the tail of the second vector to find the resultant vector, and the angle it creates.

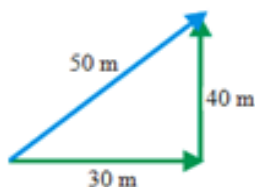




For the calculation method, draw a rough diagram of a vector triangle and draw the resultant.



Solution



$$R = \sqrt{30^2 + 40^2}$$

$$R = \sqrt{900 + 1600}$$

$$R = \sqrt{2500}$$

$$R = 50 \text{ m}$$

Use the Pythagorean theorem to find the magnitude of the resultant and use trigonometry to find the angle made by the resultant above/below the horizontal axis.

MCQs:

F/M_2024_v22

A student has a measuring cylinder containing water and also has a balance.

Which of these could she use to find the volume of a small metal sphere?

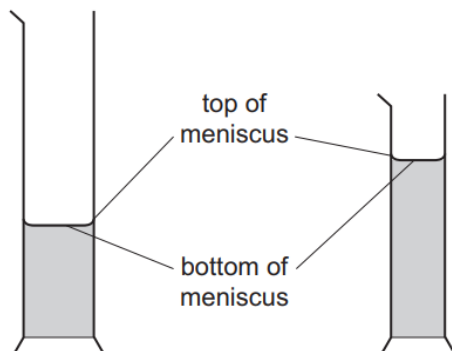
She has no other apparatus.

- A** either the measuring cylinder containing water or the balance
- B** the measuring cylinder containing water only
- C** the balance only
- D** neither the measuring cylinder nor the balance



M/J_2024_v22

A student wishes to measure accurately the volume of approximately 40 cm^3 of water. She has two measuring cylinders, a larger one that can hold 100 cm^3 , and a smaller one that can hold 50 cm^3 . The water forms a meniscus where it touches the glass.



Which cylinder and which water level does the student use to ensure an accurate result?

	cylinder	water level
A	larger one	bottom of meniscus
B	larger one	top of meniscus
C	smaller one	bottom of meniscus
D	smaller one	top of meniscus

M/J_2024_v21

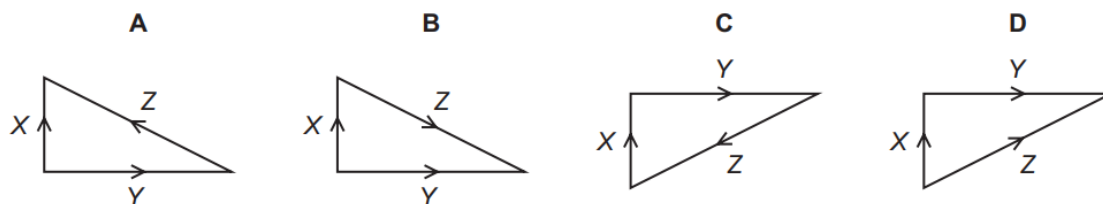
In which row are quantities correctly categorised into scalar quantities and vector quantities?

	scalar quantities	vector quantities
A	mass and energy	weight and acceleration
B	gravitational field strength and time	force and electric field strength
C	speed and momentum	distance and force
D	distance and energy	velocity and temperature



M/J_2023_v21

Which vector diagram correctly shows the force Z as the resultant of forces X and Y ?



F/M_2022_v22

A student investigates a pendulum.

He measures the time for the pendulum to complete 20 oscillations.

He repeats the experiment three more times.

The readings are shown.

experiment	time for 20 oscillations / s
1	17.6
2	19.8
3	17.6
4	18.6

What is the average period of the pendulum?

- A** 0.88 s **B** 0.92 s **C** 17.6 s **D** 18.4 s

M/J_2021_v22

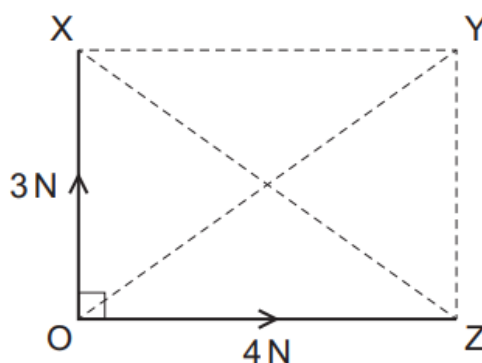
Which piece of apparatus is the most suitable for measuring the mass of a pencil sharpener?

- A** digital balance
B measuring cylinder
C newton meter
D ruler



M/J_2023_v22

Forces of 3 N and 4 N act at right angles, as shown.



What is the resultant force?

- A** 1 N along XZ
- B** 5 N along XZ
- C** 5 N along OY
- D** 7 N along OY

O/N_2023_v23

How many of the quantities shown are scalars?

- | | mass | momentum | density | energy |
|------------|------------|------------|------------|--------|
| A 1 | B 2 | C 3 | D 4 | |



ANSWERS:

B) To find the volume of a sphere either the radius of the sphere is required which can be plugged into the formula or “volume by displacement” method can be used where the sphere is added to the cylinder and the change in volume of water is equal to the volume of the sphere. As the radius is unknown the second method will be used in this case

C) As the water is 40 cm^3 the 50 cm^3 cylinder will give a more accurate reading and as water is a colourless liquid, the bottom of the meniscus is to be read for an accurate reading

A) mass and energy are scalar quantities as they only have a magnitude attached to them whereas weight and acceleration are vector quantities with magnitude and direction attached to them

D) Applying the head-to-tail rule where the head of first vector (X) is attached to tail of second vector (Y). Finally the tail of first vector is attached to head of second vector to find the resultant (Z)

B) Find average time for 20 oscillations by adding each time and dividing. Then divide that by 20 to find period of one oscillation

A) A digital balance is used to measure the mass of an object so it is the only correct option. A measuring cylinder is used to measure volume, a Newton metre to measure weight and a ruler to measure length so they are all wrong.

C) For this the head-to-tail rule needs to be applied. Vector $\rightarrow OX$ is equivalent to vector $\rightarrow ZY$ so $\rightarrow OX$ can be replaced by $\rightarrow ZY$. Now using the Pythagoras Theorem we can find the resultant force and by joining the tail of the vector $\rightarrow OZ$ to the head of $\rightarrow ZY$, we can find the resultant direction. The resultant force becomes 5N in the direction of $\rightarrow OY$ so C is our answer.

C) Out of these four quantities only momentum has direction as it considers the change in velocity. The three rest of the quantities have magnitude only and are thus scalar. So our option will be C.



Structured Questions:

A load is suspended from a thread. The vertical force on the thread due to the load is 0.75 N.

- (a) Calculate the mass of the load.

mass = [2]

- (b) Fig. 1.1 shows the load suspended from the thread.

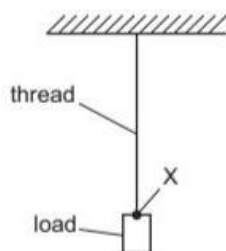


Fig. 1.1

A wire is attached to the load at point X and pulled horizontally to the right.

The tension in the horizontal wire is 1.2 N.

By drawing a scale diagram or by calculation, determine:

- the magnitude of the resultant of the force at X due to the load and due to the tension in the wire
- the direction of the resultant relative to the vertical direction.

Show your working.

magnitude of resultant force = N

direction of resultant relative to vertical = °

[4]



Answers:

Question	Answer	
1(a)	0.077 kg OR 77 g	
	$g = W / m$ OR $(m =) W / g$ OR 0.75 / 9.8	
1(b)	2 <u>vectors</u> at right angles	OR use of Pythagoras' theorem e.g. $a^2 + b^2 = c^2$ OR (force =) $\sqrt{(1.2^2 + 0.75^2)}$
	1.4 (N)	
	58(°)	
	resultant force including correct direction of arrow	OR use of trigonometry to find angle e.g. $\tan \theta = 1.2 / 0.75$

Question	Answer		Marks
1(a)	speed = 4.3 m / s	speed = 4.3 m / s	A2
	correct vector triangle or rectangle drawn	use of Pythagoras' theorem e.g. $a^2 + b^2 = c^2$ OR (speed =) $\sqrt{(2.5^2 + 3.5^2)}$	(C1)
	direction = 54° or 55°	direction = 54° or 55°	A2
	resultant velocity vector (including arrow)	use of trigonometry to find angle e.g. $\tan \theta = 3.5 / 2.5$	(C1)
1(b)	a scalar quantity distance, time, mass, energy, temperature		B1
	a vector quantity force, weight, acceleration, momentum, electric field strength, gravitational field strength		B1



Question	Answer	Marks
1(a)(i)	(magnitude of velocity =) 0.90 m / s	A2
	use of Pythagoras' theorem e.g. $a^2 + b^2 = c^2$ OR (speed =) $\sqrt{(0.54^2 + 0.72^2)}$	C1
	OR correct vector triangle or rectangle drawn	
	(direction of velocity =) 53° (to riverbank)	A2
	use of trigonometry to find angle e.g. $\tan \theta = 0.72 / 0.54$ OR (only) angle with horizontal identified on the diagram	C1
1(a)(ii)	(distance =) 81 m	A3
	$v = s / t$ OR ($s =$) vt OR ($s =$) $0.9(0) \times 90$	C1
	(time =) 1.5×60 (= 90) OR (time =) 90	C1



Unit 1.3-1.8: Dynamics (Motion, Forces, Moments, Energy, Work and Power)

Topic 1.3: Mass and Weight

What is mass?

Mass is a measure of the quantity of matter in an object, relative to an observer.

It is sometimes also referred to as the resistance to motion of an object.

Mass is measured in kilograms or kg.

The mass and weight of an object are NOT the same property.

Weight and Gravitational Field Strength

The weight of an object is the gravitational force that acts on it.

It is measured in Newtons(N).

Hence, the weight of an object can change depending on the gravitational field strength of a mass.

The gravitational field strength is defined as the force of gravity per unit mass.

It is defined by the equation $g = W/m$, where g = gravitational field strength, W = weight/force of gravity, and m = mass.

g is also equivalent to the acceleration of free fall of the planet in question.

Any object in free fall in a vacuum will fall with the same acceleration g .



Mass vs Weight

Weight is a vector quantity whereas mass is a scalar quantity.

Weight can vary but mass will always remain the same.

Weights and mass can both be measured but mass is measured using a balance while weight can be measured using a spring scale.



The above shown spring scale/spring balance is used to measure weight by attaching a mass to it and then measuring how many newtons of force it can pull downwards, towards the Earth.



A digital mass balance, shown above, measures only the mass of the object and not its weight.

Balances can be used to compare the different masses and weights of different objects.



An object can only have weight when the planet it is on has gravity, because weight is the effect of a gravitational field on a mass, meaning it is the force of gravity with which a planet/star pulls a mass towards itself.

On Earth, gravity pulls objects downwards, which is why they fall, and thus why weight always acts downwards.

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Topic 1.4:Density

Defining Density

An object's density is its mass occupied per unit volume and is measured in kg/m^3 or g/cm^3 .

The formula for density of a solid is $\rho = m/v$, where ρ = density, m = mass and v = volume.

The density of an object is a value of how concentrated its mass is.

The density of water is 1000 kg/m^3 OR 1 g/cm^3

Calculating density of a liquid

The density of a liquid can be calculated using the formula $\rho = m/v$.

Firstly, the liquid can be added to a measuring cylinder. Then, the volume can be measured.

The mass of the measuring cylinder with and without the liquid should be measured, using a balance.

Mass of liquid = Mass of measuring cylinder with liquid – Mass of measuring cylinder without liquid

The formula above can be used to find the density since both mass and volume are known.

Calculating density of Solids

The equation of density, $\rho = m/v$, is once again used to find the density of solids.

For a regular solid, the mass can be measured using a balance and the volume can be calculated by measuring dimensions and using the appropriate formula. Then, the equation above can be used to find density.

For an irregular solid, the mass can still be measured using a balance.



The volume, however, will now be measured using the volume by displacement method (discussed in Topic 1.1).

Then the equation above can be used to find the density.

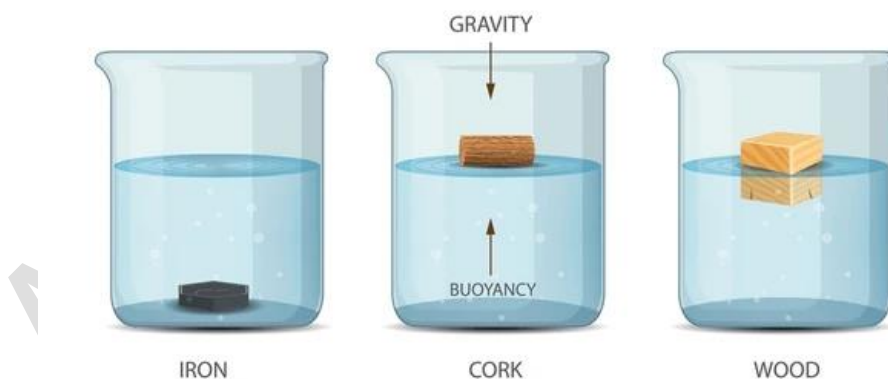
Role of Density in floating

An object will float in a liquid if its density is less than that of the liquid, and it will sink if its density is more than that of the liquid.

This is because density is the measure of how concentrated an object's mass is, and the object which has a more concentrated mass will tend to sink.

(Note that Archimedes principle or buoyancy is not included in your course)

ARCHIMEDES PRINCIPLE



Two liquids can also float above each other, given that they are immiscible (meaning they will not mix). Much like solids, here the denser liquid will sink and form the bottom layer while the less dense liquid will float and form the top layer (example given below).



Topic 1.5: Forces

What is force?

Force can be defined as

“A push or a pull that acts on an object due to the interaction with another object”

Forces can have an effect on

Speed

(for eg. pushing a shopping cart, launching a rocket)

Direction

(for eg. returning a tennis serve, gravitational pull on a comet)

Shape

(for eg. hammering metal into car body shapes)

Size

(for eg. stretching a rubber band, pushing a spring)

What is a resultant force?

When two or more forces act on an object, they seem to act as a single force with a particular magnitude and direction; this is the resultant

A resultant force is a single force that describes all of the forces operating on a body

This single resultant force determines:

The direction in which the object will move as a result of all of the forces

The magnitude of the net force experienced by the object

Balanced and unbalanced forces?

Forces are balanced if multiple forces act in opposing directions with an equal magnitude in each direction

The effects of the forces then cancel out

There is no resultant force in that plane of direction



Forces are unbalanced if the effects of the forces acting in each plane do not cancel out

There is a resultant force in one or more planes of direction

Calculating resultant force

Force is a vector quantity, it has both magnitude and direction

When adding forces together, it is important to assign positive and negative values to show the direction in which the forces are acting

If forces are being applied in the the same direction (on the same plane of action), they are added (e.g pushing an already moving cart)

If forces are being applied in the the opposite direction (on the same plane of action), they are subtracted (e.g stopping a rolling ball)

Newton's First law of motion

Newton's First Law of Motion states:

"Objects will remain at rest, or move with a constant velocity unless acted on by a resultant force"

Newton's first law means if the resultant force acting on an object is zero:

A stationary object will remain stationary

An object moving in a straight line at a constant speed will continue to move in a straight line at a constant speed

When the resultant force is not zero, it accelerates

The speed of the object can change

The direction of the object can change

Newton's Second law of motion

Newton's second law of motion states:

"The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to the object's mass"

A resultant force acting on an object will cause a change in the object's motion

This change in motion is an acceleration:

Speeding up

Slowing down

Changing direction



If the resultant force on an object is not zero, the object will accelerate in the direction of the resultant force

The bigger this resultant force, the larger the acceleration

For a given force, the greater the object's mass, the smaller the acceleration experienced

This can be expressed in the form:

$$F = ma$$

Where:

F = resultant force on the object, measured in newtons (N)

m = mass of the object, measured in kilograms (kg)

a = acceleration of the object, measured in metres per second squared (m/s^2)

The acceleration occurs in the same direction as the resultant force

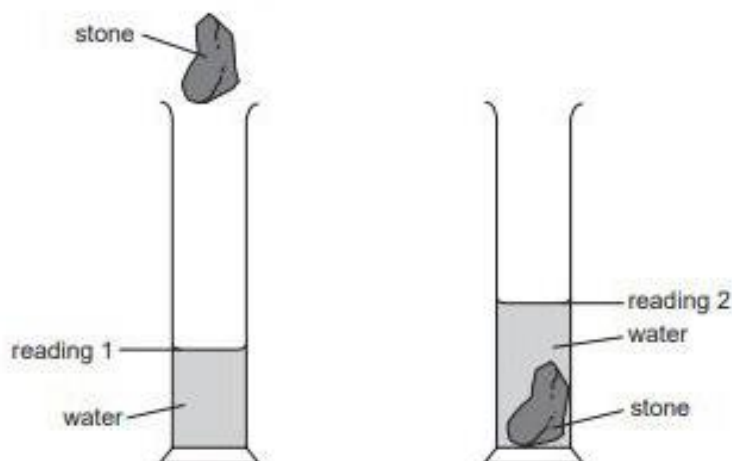


MCQs:

- 1 A student wishes to determine the density of an irregularly-shaped stone.

First he finds the mass of the stone. Next he lowers the stone into a measuring cylinder containing water.

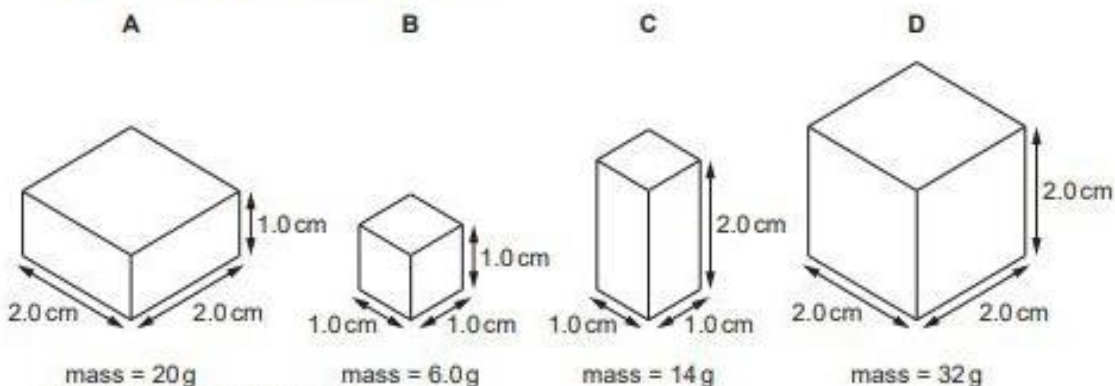
The diagrams show the measuring cylinder before and after the stone is lowered into it.



How should the student calculate the density of the stone?

- A mass of stone $\times$ reading 2
 - B mass of stone $\times$ (reading 2 – reading 1)
 - C mass of stone $\div$ reading 2
 - D mass of stone $\div$ (reading 2 – reading 1)
- 2 The diagrams show the dimensions and masses of four regular solid objects. The objects are made from different metals.

Which metal has the greatest density?





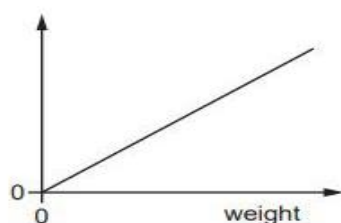
Four different children run up the same set of stairs.

For which child is the useful power to climb the stairs the greatest?

	mass of child / kg	time taken / s
A	40	15
B	50	25
C	60	25
D	70	15

A student adds weights to an elastic cord. He measures the length of the cord for each weight.

He then plots a graph from the results, as shown.

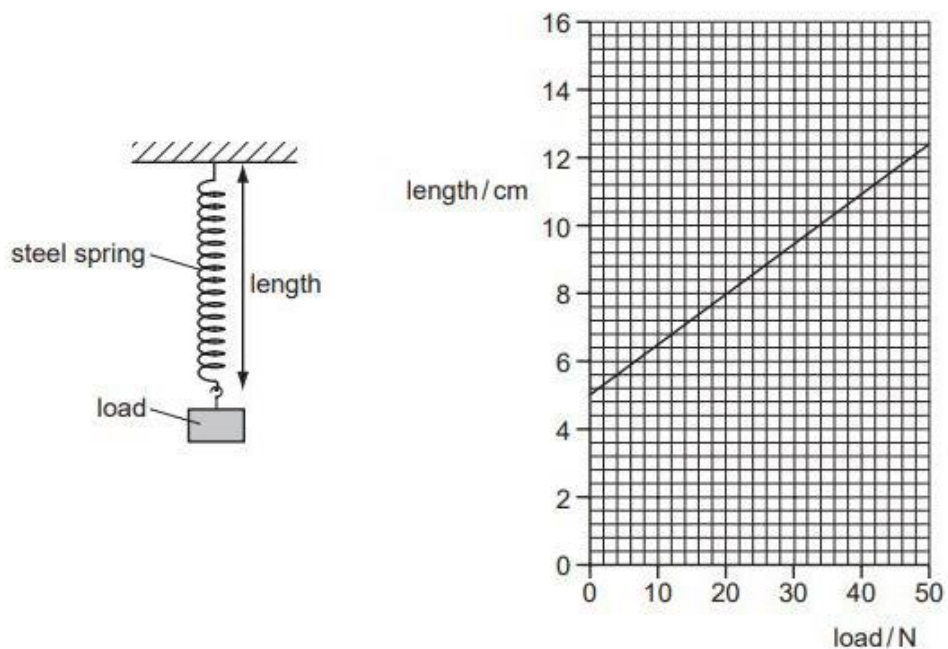


What has he plotted on the vertical axis?

- A** measured length
- B** original length
- C** (measured length + original length)
- D** (measured length – original length)



The diagrams show a steel spring and a graph of its length against the load applied to it.

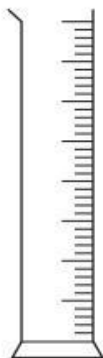


What is the extension of the spring when a load of 20 N is applied to it?

- A** 3.0 cm **B** 4.5 cm **C** 5.0 cm **D** 8.0 cm



The diagram shows a measuring instrument.



Which quantity is this instrument used to measure?

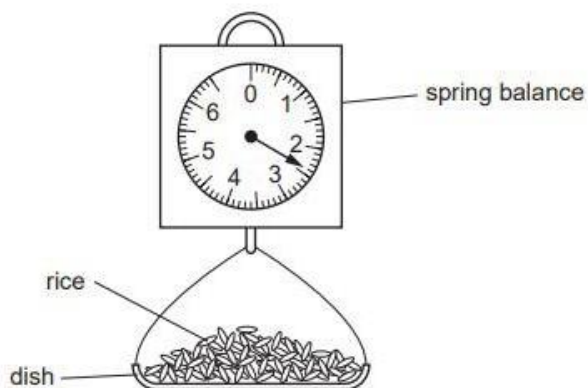
- A area
- B density
- C mass
- D volume

Which option contains **only** apparatus that could be used to determine the volume of a small block of unknown material?

- A measuring cylinder, metre rule
- B measuring cylinder, stopwatch
- C metre rule, balance
- D metre rule, stopwatch



A customer goes to a market and buys some rice. The stallholder pours rice into a dish that hangs from a spring balance. He records the reading on the spring balance.



The customer then buys some pasta and the stallholder notices that the reading on the spring balance, with just pasta in the dish, is the same as it was with just rice in the dish.

The rice and the pasta must have the same

- A density.
- B temperature.
- C volume.
- D weight.

Answer

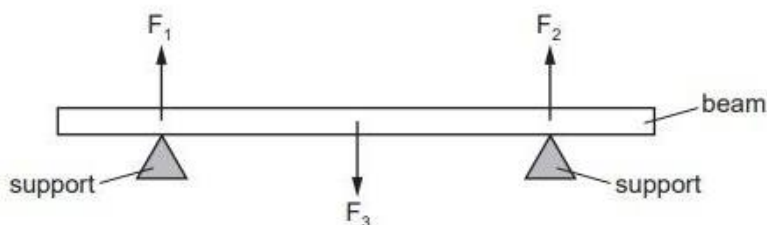
The mass of an astronaut is 70 kg on the Moon.

What is the mass of the astronaut on the Earth?

- A 7 kg
- B 70 kg
- C 80 kg
- D 700 kg



A heavy beam rests on two supports. The diagram shows the only three forces F_1 , F_2 and F_3 acting on the beam.



The beam is in equilibrium.

Which statement is correct?

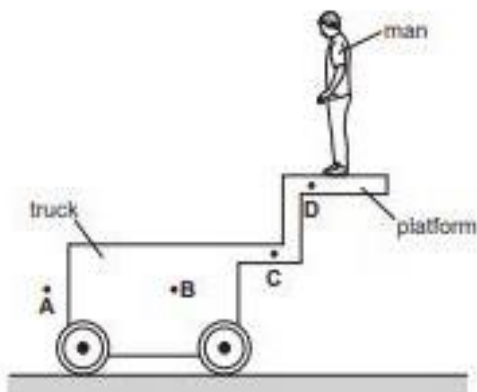
- A All the forces are equal in size.
- B The resultant force on the beam is in the opposite direction to the resultant turning effect.
- C The resultant force on the beam is zero and the resultant turning effect on the beam is zero.
- D The total upward force is twice the total downward force.

A heavy truck on wheels has a platform attached to it.

A man stands on the platform.

The truck does not fall over.

Which position **A**, **B**, **C** or **D** could be the centre of mass of the whole system (truck, platform and man)?



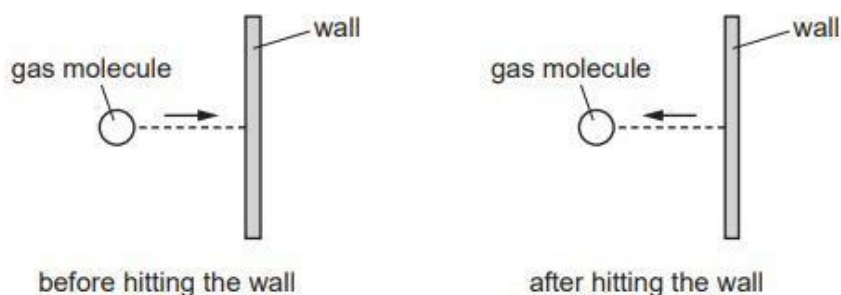


An object of mass 50 kg accelerates from a velocity of 2.0 m/s to a velocity of 10 m/s in the same direction.

What is the impulse provided to cause this acceleration?

- A** 250 N s **B** 400 N s **C** 850 N s **D** 2500 N s

A gas molecule strikes the wall of a container. The molecule rebounds with the same speed.

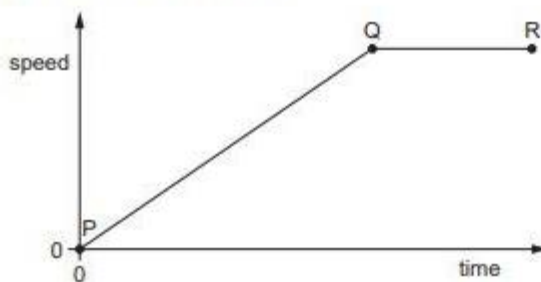


What happens to the kinetic energy and what happens to the momentum of the molecule?

	kinetic energy	momentum
A	changes	changes
B	changes	stays the same
C	stays the same	changes
D	stays the same	stays the same



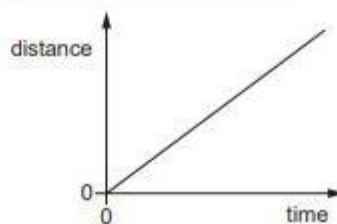
The speed-time graph shows the motion of a car.



Which row describes the motion?

	between P and Q	between Q and R
A	accelerating	moving at constant speed
B	accelerating	not moving
C	moving at constant speed	decelerating
D	moving at constant speed	not moving

The diagram shows the distance-time graph of an object.



Which statement describes the object?

- A** It is accelerating.
- B** It is moving at a constant speed.
- C** It is slowing down.
- D** It is stationary.



Answers:

Answer:D Explanation: Density = mass/volume and thus for density of the rock we need to divide its mass with its volume. The volume of the rock can be found by displacement in which the change in volume of the liquid level equals the volume of the rock making D the answer

Answer:C Explanation: Density = mass/volume and thus for this question we can calculate the density of each object individually by dividing mass with volume (product of every side). This gives us 5,6,7,4 for A,B,C,D respectively making C the correct answer

Answer:D Explanation: Power = work done/time and as work done in this scenario is the gain in GPE of the children we can rewrite the equation as mgh/t . Moreover as g and h are constant we can conclude that Power is directly proportional to mass and inversely proportional to time $P=m/t$. Thus the lowest time with the highest mass gives us the highest power making D the correct option

Answer:D Explanation: Tidal, wave and hydroelectric energy sources use the movement of water to turn turbines while nuclear energy uses energy to boil water and produce steam to turn turbines

Answer:D Explanation: The graph shown is for two quantities that are directly proportional as it is a straight line that passes through the origin (0,0). As weight is one of the quantities for a cord, it is directly proportional to extension which is measured length - original length, making D the correct answer

Answer:A Explanation: The question is asking for the extension which is measured length - original length. At 20N the measured length is 8 while the original length is 5, making the extension 3

Answer:D Explanation: The instrument shown is a measuring cylinder which is used to measure volume of a liquid

Answer:A Explanation: A measuring cylinder can be used to measure volume of the block by displacement while metre rule can be used to make measurements and calculate volume through formula.

Answer:D Explanation: A spring balance is used to determine the weight of an object. It does not measure temperature or volume, so B and C are wrong. The density of an object is measured by the formula density = mass/volume, and since none of those quantities are measured by the weighing balance, A is also wrong leaving D as the only logical answer.

Answer:B Explanation: The correct answer is B since weight can change depending on the gravitational field strength but mass always remains constant.

Answer:C Explanation: Since the beam is in equilibrium, then according to the principle of moments, the resultant torque must be zero and the resultant force must be zero. A is wrong because if $F_1=F_2=F_3$ then total upwards force, F_3 , is not equal to total downward force, F_1+F_2 . B is impossible because the beam has no torque or resultant direction so they cannot be opposite to each other. C matches with the law of static equilibrium and is correct. D is wrong because it suggests that the total upward force is not equal to 0.



Answer: B Explanation: Option A is wrong since the point is not even inside the system. Option B is correct because a broader base and lower centre of gravity indicates more stability. Options C and D are both incorrect because they indicate higher centres of gravity than B and narrower bases, so it is likely that the man would have fallen over if any of them were the actual centre of gravity.

Answer: B Explanation: The impulse of an object is the same as the change in its momentum. This is given by the formula $I = m(v - u)$, where I = impulse, m = mass, v = final velocity and u = initial velocity. So $I = 50((10) - (2)) = 50(8) = 400$ Ns. So the answer is B.

Answer: C Explanation: Since the speed is the same and mass remains constant, kinetic energy also remains the same because $K.E = \frac{1}{2} * m * v^2$. However, since momentum is a vector quantity, it will change because it also includes direction and the direction of the molecule has changed.

Answer: A Explanation: This is a speed-time graph and from P to Q the speed is clearly increasing over time so the car is accelerating. This rules out C and D. From Q to R the car is still moving at a constant speed above zero so it is not at rest. This means B is also eliminated making A the answer.

Answer: D Explanation: This is a distance-time graph in the diagram. Since the gradient of a distance time graph is speed and the gradient is uniform throughout the whole graph, it means speed is constant, so D is correct. The other options are all wrong.



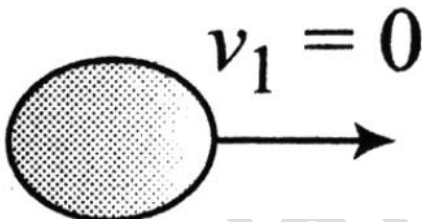
Topic 1.6:Momentum

Defining momentum:

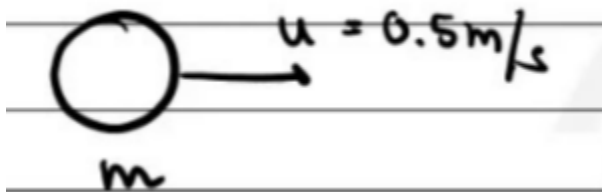
Momentum is the product between mass and velocity.

Velocity is a vector quantity; therefore, momentum is also a vector quantity hence we have to focus on direction and make sure to use opposite sign with opposite direction.

The unit for momentum is “Ns” or “ $kg\ m/s$ ” where kg is mass and m/s is speed therefore we derive the formula that momentum = mv where “m” is mass and “v” is velocity. When mass increases, momentum increases. When velocity increases, momentum increases.



As shown in the above example, suppose that a ball with mass 5 kg is at rest (velocity is zero). To calculate its momentum we can apply the formula $p = mv$ where p is momentum. $p = (5)*(0)$ thus the momentum is zero.

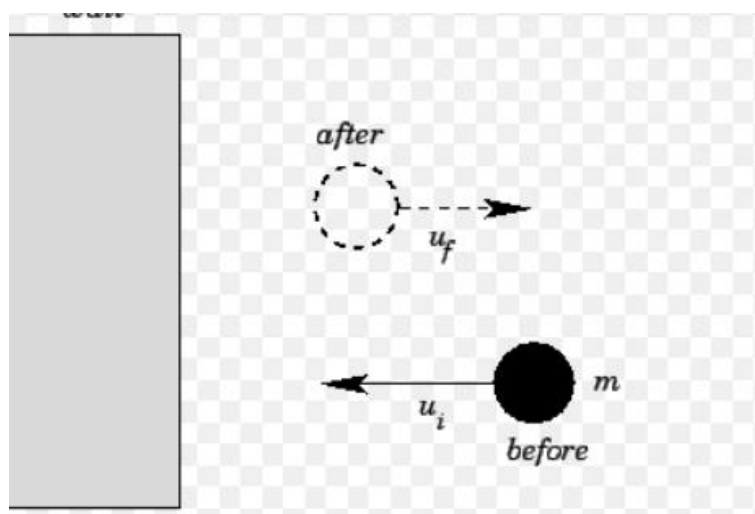




As shown in the next diagram, a ball is moving with a velocity of 0.5 m/s. Suppose its mass is 10 kg. To calculate momentum, $0.5 \times 10 = 5 \text{ kgm/s}$.

Change in Momentum:

It is the difference between initial and final momentum. Its formula is $\Delta p = mv - mu$ where “ Δ ” means change, mv is final momentum and mu is initial momentum.



In the above example, a ball hits the wall and then comes back. Suppose the ball has mass 4 kg. u (velocity before hitting the wall) = 5 m/s and v (velocity after hitting the wall) = -3 m/s. Here negative “-” sign is used because direction is opposite and velocity is a vector quantity so to show this we use “-” sign.

Applying formula: change in momentum = mv (final momentum) - mu (initial momentum) = $m(v-u) = 4((-3)-(5)) = 32 \text{ kgm/s}$.

Newton's second Law:

Rate of change of momentum is directly proportional to the force. $F = k$ (change in momentum/time) where k is a constant (1) hence

$F = ((mv - mu)/t) \rightarrow F = m((v - u)/t) \rightarrow F = ma$ where “ m ” is mass and “ a ” is acceleration.



Defining Force:

Force is the rate of change of momentum.

Resultant Force:

$$F = ((mv - mu)/t)$$

Thus resultant force “ F ” = change in momentum/time or = ma .

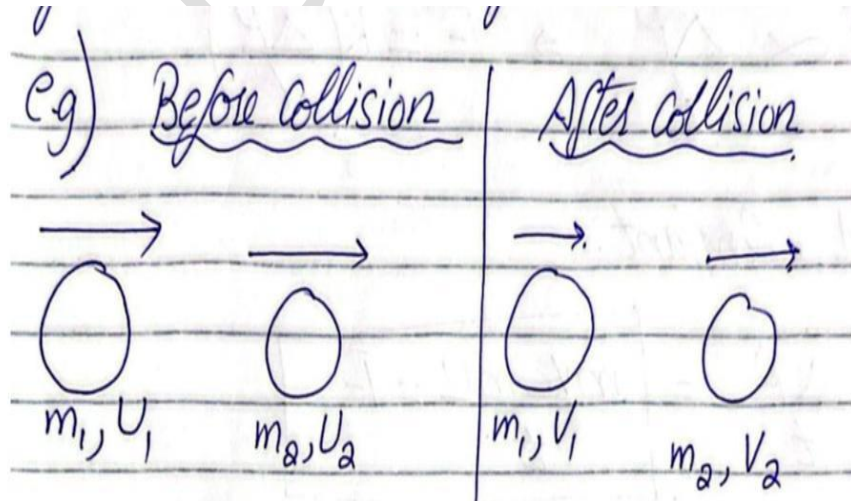
Defining Impulse:

It is the product between force and time.

$$F \cdot t = mv - mu \text{ thus change in momentum} = \text{impulse} = F \cdot t.$$

Principle of the Conservation of Momentum:

In an enclosed/isolated system the sum of momentum before collision equals to sum of momentum after collision thus momentum is conserved.



In the above example, two balls are moving and they collide with each other and move separately. “ u ” is velocity before collision and “ v ” is velocity after collision. In this case *principle of momentum* can be applied.



$$m_1u_1+m_2u_2 = m_1v_1+m_2v_2.$$

In any case if the balls stick together after collision and move together then we can apply formula:

$m_1u_1 + m_2u_2 = (m_1+m_2)v$ where “v” is combined velocity.

MCQs:

QUESTION:1

An object of mass 4.0 kg is moving with a velocity of 3.0 m/s in a straight line.

What is the momentum of the object?

- A** 0.75 kgm/s **B** 1.3 kgm/s **C** 12 kgm/s **D** 24 kgm/s

QUESTION:2

An object is moving at +3.0 m/s.

A force acts on the object.

After a time, the object is moving at –4.0 m/s.

The mass of the object is 5.0 kg.

What is the change in momentum of the body?

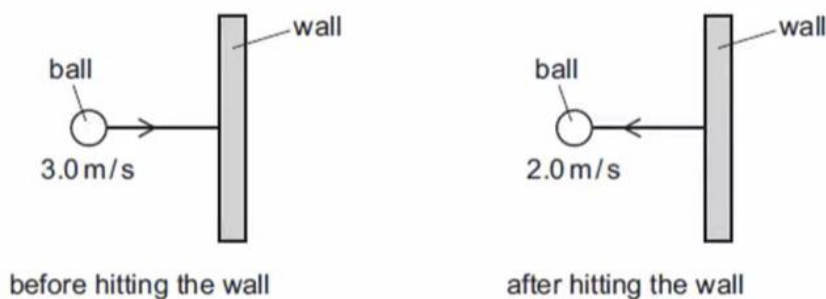
- A** –35 kgm/s **B** –5.0 kgm/s **C** +5.0 kgm/s **D** +35 kgm/s



QUESTION:3

A ball has a mass of 0.30 kg . It moves horizontally with a speed of 3.0 m/s in the direction shown.

The ball hits a wall.



The ball rebounds from the wall with a horizontal speed of 2.0 m/s .

What is the change in momentum of the ball?

- A 0.30 kgm/s B 1.0 kgm/s C 1.5 kgm/s D 5.0 kgm/s

QUESTION:4

A ball with 3.0 N force hitting on a wall, and have contact with the wall for 2minutes. Calculate the impulse.

- A 6.0 Nm B 360 Ns C 6.0 Ns D 0.025 N/s



QUESTION:5

An object of mass 3.0 kg, travelling at a speed of 6.0 m/s, collides with an object of mass 2.0 kg, travelling in the opposite direction at a speed of 2.0 m/s.



The objects stick together during the collision.

What is the speed and direction of the combined mass after the collision?

- A 4.4 m/s to the left
- B 4.4 m/s to the right
- C 2.8 m/s to the left
- D 2.8 m/s to the right

QUESTION:6

A car of mass 1000 kg travelling at 8.0 m/s collides with a lorry of mass 3000 kg that is travelling at 2.0 m/s in the same direction. After colliding, the two vehicles stick together.

What is their speed after the collision?

- A 2.0 m/s B 2.5 m/s C 3.5 m/s D 5.0 m/s

QUESTION:7

A footballer kicks a stationary football.

His foot is in contact with the ball for 0.050 s.

The mass of the ball is 0.40 kg.

The speed of projection of the ball is 25 m/s.

What is the average force exerted on the ball by his foot?

- A 0.32 N B 0.50 N C 200 N D 1300 N



QUESTION:8



A tennis ball has a mass of 57 g.

A tennis player hits the tennis ball with a tennis racket. The tennis ball has a velocity of 25 m/s when it hits the racket.

The velocity of the tennis ball when it leaves the player's racket is 15 m/s in the opposite direction from its approaching direction.

The average force exerted by the tennis racket on the ball is 35 N.

For how long is the tennis ball in contact with the tennis racket?

- A** 0.015 s **B** 0.016 s **C** 0.065 s **D** 0.65 s



Answers:

Q1) C: $P=mv=(4)(3)=12\text{kgm/s}$

Q2) A: change in momentum = $m(v-u)=5(-4-3)=-35\text{kgm/s}$

Q3) C: change in momentum = $m(v-u)=0.3(-2-3)=-1.5\text{kgm/s}$

Q4) B: Impulse = $F \times T = 3 \times (2 \times 60) = 360\text{Ns}$

Q5) D: momentum of ball with mass 3 kg is 18kgm/s and of ball with mass 2kg is -4kgm/s . Total momentum is $18-4=14\text{kgm/s}$. $mv=14$, $v=14/m$
 $v=14/(5)=2.8\text{m/s}$

Q6) C: Momentum of car = $1000 \times 8 = 8000\text{kgm/s}$ and Momentum of Lorry = $3000 \times 2 = 6000\text{kgm/s}$. Total momentum = $8000+6000=14000\text{kgm/s}$.
 $mv=14000$ $v=14000/\text{total combined mass} = 14000/4000=3.5\text{m/s}$

Q7) C: Impulse = change in momentum = $F \times t = mv$ ($mu=0$) $F=mv/t = (0.4 \times 25)/0.05 = F=200\text{N}$

Q8) C: Impulse = change in momentum = $F \times t = m(v-u)$ $t=m(v-u)/F$
 $= 0.057\text{kg}(-15-25)/35 = t=0.065\text{s}$ (ignore negative sign)



Unit 1.7: Energy, Work and Power

ENERGY

Energy is ability to do work

Its SI unit is “J” which stands for Joules

There are different forms of energy i.e

1)Kinetic energy:

Energy related with the motion of an object

Formula: $\frac{1}{2}(m)(v)^2$ where “m” is mass of the object in Kilograms and “v” is Velocity is m/s.

2)Gravitational potential energy:

Energy related with an object due to its position(height)

Formula: mgh where “m” is mass in Kilograms “g” is gravitational force acting on the object (9.81N on Earth) and “h” is height of the object from the surface in meters.

3)chemical energy:

Energy stored in humans, foods, batteries, and cells etc

4)elastic energy:

Energy stored in any stretched object

5)nuclear energy:

Energy given by nuclear power plant

6)electrostatic energy:

Energy stored in form of electricity

7)internal energy:

Energy related with molecules in any system

PRINCIPLE OF ENERGY: Energy cannot be created nor destroyed, it just changes forms i.e energy is transferred during events and processes.

Example 1)

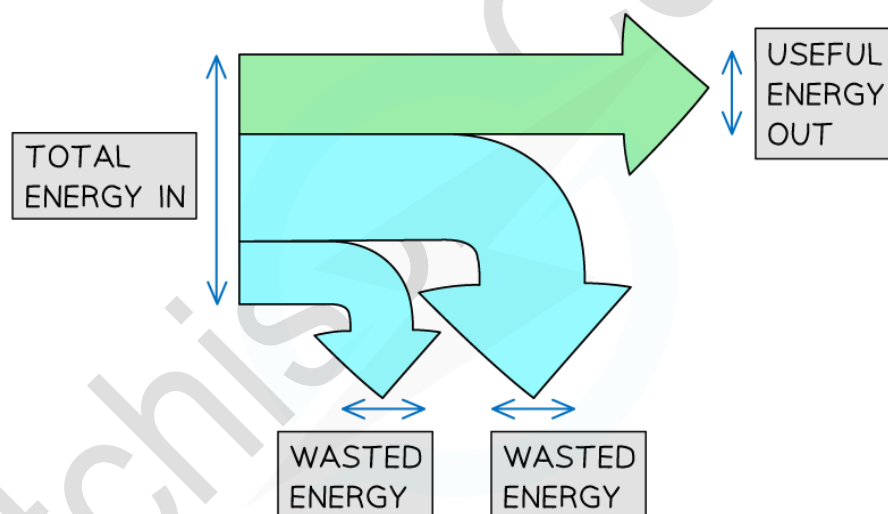
if an object is on a height of 10m and has mass 10kg then it has gravitational potential energy of 981J and when it drops, energy is



converted from Gravitational potential energy to Kinetic energy (due to its speed). In this case not all Gravitational Potential energy is converted into Kinetic energy because some energy may be lost as heat. But if given that there is no heat energy lost then Gain in kinetic energy will be equal to Loss in Gravitational potential energy and formula to calculate Kinetic energy will be: $\frac{1}{2} (m)(v)^2 = mgh$ ("m" can be canceled out thus we don't need mass of an object in this case)

Example 2)

When a candle is burning then chemical energy is converted to heat and light energy



This Sankey diagram shows how energy is converted and wasted during events or processes.

POWER:

Power is work done per unit time or energy transferred per unit time.

Its SI unit is Watt "W" or "J/s"

Power= Work/time = $(F \times d)/\text{Time}$

Power= Energy/time = $mgh/\text{time} = \frac{1}{2}(m)(v)^2/\text{time}$



MCQs:

F/M_2024_v22

A ball is falling towards the ground.

Which transfer between energy stores is taking place?

- A** elastic energy to kinetic energy
- B** gravitational potential energy to elastic energy
- C** gravitational potential energy to kinetic energy
- D** kinetic energy to gravitational potential energy

M/J_2024_v21

A coal-fired power station generates electricity. Coal is burned and the energy released is used to boil water. The steam from the water makes the generator move and this produces electricity.

Which row gives the name of the energy store in the coal and the energy store of the moving generator?

	coal	generator
A	chemical	hydroelectric
B	chemical	kinetic
C	geothermal	hydroelectric
D	geothermal	kinetic



F/M_2023_v22

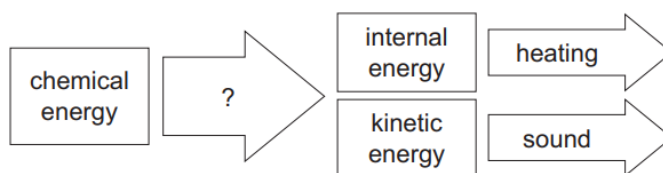
A machine has a power input of 200 W and a useful output energy of 1 kJ in 6 minutes.

What is the efficiency of the machine?

- A** 0.014% **B** 0.83% **C** 1.4% **D** 83%

M/J_2023_v22

The diagram shows the energy stores for a mobile (cell) phone and how the energy is transferred between stores.



What describes how the chemical energy is transferred?

- A** electrical work done
B mechanical work done
C electromagnetic waves
D sound waves



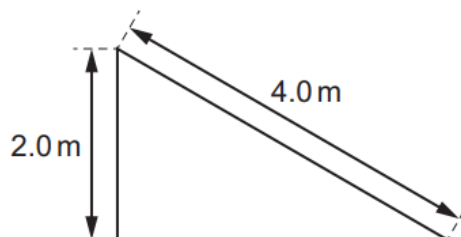
O/N_2023_v22

A box is initially at rest at the top of a rough slope.

The box slides down the slope.

The weight of the box is 20 N.

The slope is 4.0 m long and 2.0 m high.



The box does 10 J of work against friction as it slides down the slope.

What is the speed of the box as it reaches the bottom of the slope?

- A** 5.4 m/s **B** 6.3 m/s **C** 7.1 m/s **D** 9.5 m/s

O/N_2022_v21

An object has kinetic energy of 200 J.

A constant resultant force of 190 N is applied in the direction of its motion through a distance of 10 m.

What is the final kinetic energy of the object?

- A** 390 J **B** 1700 J **C** 2000 J **D** 2100 J



M/J_2021_v21

Which situation involves no work being done and no energy being transferred?

- A** a car skidding to a stop on a road
- B** a crane lifting a load
- C** a heavy load hanging from a strong bar
- D** a student dragging a big box over a rough floor

M/J_2020_v22

A car of mass 500 kg is moving at 10 m/s. The engine does work on the car and the speed increases to 16 m/s.

How much work is done by the engine to increase the speed of the car?

- A** 3000 J **B** 9000 J **C** 39000 J **D** 78000 J

Answers:

Refer to relevant marking schemes.



Structured:

O/N_2020_v41

- (c) The metal ball has a mass of 2.1 g. It falls a distance of 0.80 m between being released and reaching the bottom of the tube.

- (i) Calculate the gravitational potential energy transferred from the ball as it falls.

gravitational potential energy transferred = [2]

- (ii) When the ball reaches the bottom of the tube, it has a speed of 1.2 m/s. Calculate the kinetic energy of the ball at the bottom of the tube.

kinetic energy = [3]

- (iii) Explain why the value calculated in (c)(i) is different from that calculated in (c)(ii).

.....

..... [1]

Aitchison



F/M_2021_v42

A power station burns waste materials from farm crops to generate electricity.

- (a) State and explain whether this process is renewable.

statement

explanation

[2]

- (b) The power station uses some of its waste thermal energy to heat water for houses in a nearby town.

State **one** problem of using waste energy in this way if the power station is far from the town.

.....

Suggest a way of reducing this problem.

.....

[2]

- (c) State **two** environmental consequences of burning coal to generate electricity.

consequence 1.

consequence 2.

[2]

Aitchison



M/J_2022_v43

Water is held behind a dam in a hydroelectric power scheme.

- (a) State the main form of energy stored in the water behind the dam.

..... [1]

- (b) The water is released from the dam and falls a vertical height of 410m at a rate of 480kg/s.

- (i) Calculate the rate at which energy is transferred by the falling water.

rate of energy transfer = [3]

- (ii) The power scheme supplies a current of 270A at a voltage of 6000V.

Calculate the efficiency of the power scheme.

efficiency =% [3]

- (c) Hydroelectric energy is a renewable form of energy.

- (i) State **one** disadvantage of hydroelectric power schemes.

..... [1]

- (ii) State **one** other renewable source of energy.

..... [1]



F/M_2023_v42

- (a) State the principle of conservation of energy.

.....
.....
..... [2]

- (b) A wind turbine has a maximum output power of 1.8 MW. The turbine operates at maximum power for 4.0 h.

- (i) Define the unit kWh.

.....
.....
..... [1]

- (ii) Calculate the energy produced by the wind turbine operating at maximum power for 4.0 h. Give your answer in kWh.

energy = kWh [2]

- (c) Radiation from the Sun is the main source of energy for most of our energy resources.

State **two** energy resources that are **not** due to radiation from the Sun.

.....
..... [2]



Answers:

1)

(c)(i) As the ball falls to the bottom, all the GPE is changed to other forms of energy so initial total GPE = total GPE transferred

$$\Delta \text{GPE} = mg\Delta h$$

$$\Delta \text{GPE} = 2.1/1000 \times 0.80 \times 9.81$$

$$\Delta \text{GPE} = 0.01648... \approx 0.016\text{J OR } 1.6 \times 10^{-2}\text{J}$$

(ii) Kinetic Energy = $\frac{1}{2}mv^2$

$$\text{K.E} = \frac{1}{2} \times 2.1/1000 \times 1.2^2$$

$$\text{K.E} = 1.5 \times 10^{-3}$$

(iii) While falling down, some energy is dissipated as heat/sound due to work done against drag, so not all the GPE is transferred to K.E.

2)

(a) Statement: It is renewable.

Explanation: More crops can always be grown by the farmers and they will continue producing waste materials.

(b) (This part is more related to thermal physics). It is possible that the water may cool down as it is transported long distances so some thermal energy will be lost. To prevent this, we can insulate the pipes(or any vessel) in which the water is transported to prevent any loss of heat.

3)

Gravitational Potential Energy (because water is stored at the top of the dam and when it falls the GPE is converted to K.E of moving water which then pushes and rotates the turbines to produce Hydroelectricity).

(b)(i) Rate of Energy Transfer = Power

$$\text{Power} = \text{Energy/Time}$$

$$\text{Energy of falling water} = \text{G.P.E of water, G.P.E} = mgh$$

$$E = mgh$$

$$\text{Power} = (410 \times 9.81 \times 480)/\text{Time}$$

$$\text{Power} = 1.930... \times 10^6 \text{J/s} \approx 1.9 \times 10^6 / 1\text{s}$$



$$P = 1.9 \times 10^6 \text{ J/s}$$

(ii) (You will study this in greater detail later).

For now use the formula Electrical Power = VI

Where V = Voltage and I = Current

Explanation:

$$\text{Efficiency} = \frac{\text{Useful Power output}}{\text{Total Power input}} \times 100\%$$

Total Power input = Power given to Power Scheme = Rate of GPE transfer

Useful Power output = Power produced by power scheme

$$\text{Useful power output} = VI = 6000 \times 270 = 1.62 \times 10^6 \text{ J/s}$$

$$\text{Total power input} = 1.93 \times 10^6 \text{ J/s}$$

$$\text{Efficiency} = (1.62 \times 10^6 / 1.93 \times 10^6) \times 100\%$$

Efficiency = 83.91... $\approx 84\%$ (This answer is slightly different from the marking scheme because they have used the value of g as 10).

(c)(i) Damage to fish habitats/ Risk of flooding/ Loss of land

(ii) (Write any one). Solar/Wind/Geothermal/Tidal/Waves/Biofuel

4)

(a) The principle of conservation of energy states that energy cannot be created or destroyed, rather it can only be changed from one form to another.

(b)(i) (You will also learn more about this in electrical power). One kWh is the amount of energy transferred in one hour at the rate of transfer of 1kW (which equals $3.6 \times 10^6 \text{ J}$).

(b)(ii) Use the definition above to help you.

$$P = E/t$$

$$E = P \times t, E = 1.8 \times 10^6 \times 4 \times 3600$$

$$E = 2.592 \times 10^{10} \text{ J}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

$$2.592 \times 10^{10} / 3.6 \times 10^6 = 7200 \text{ kWh}$$



- (c)
1. Geothermal (This energy is derived from under the Earth).
 2. Nuclear (This energy is produced via Uranium which the Sun cannot produce as its nuclear fusion produces smaller metals).
 3. Tidal (Tides are also created by the moon so it can produce this energy).



Topic 1.8: Pressure

What is pressure?

Pressure is defined as the force per unit area acting on a surface.

It is measured in Pascals(Pa).

The equation for pressure is $P=F/A$, where P=pressure, F=Force and A=area.

Pressure is inversely proportional to area which means that if area in contact with the surface is reduced then pressure will increase.

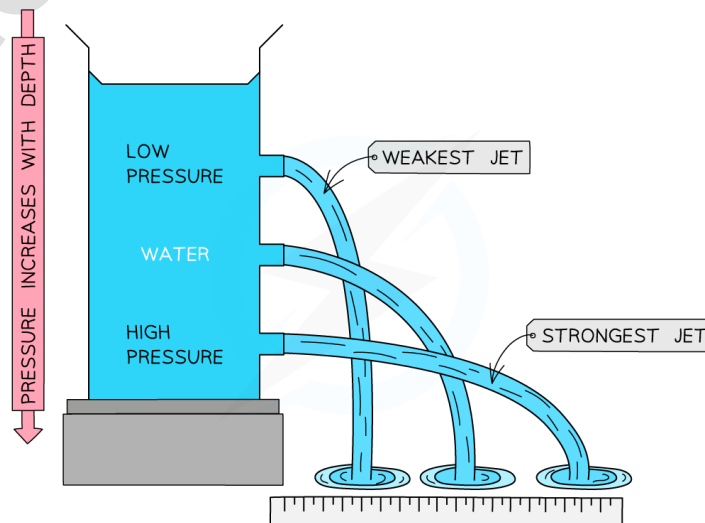
Pressure is directly proportional to Force which means more the force applied on an object more the pressure it exerts.

Eg: a knife is sharpened so that fruits are easily sliced. It is sharpened to reduce its area in contact with the surface of fruit and with the same force applied, fruit is easily sliced.

Atmospheric pressure is approximately 100,000Pa

To determine pressure on an object placed in liquid the formula is Pressure in liquids= ρgh where “ ρ ” is density of the liquid “g” is gravity and “h” is height or distance between surface of liquid and object (depth)

We can see by the formula that width of any container has no effect on pressure.





In the above example we can see that the water with most depth is released with greatest pressure and moves the furthest whereas water with lowest depth has lowest pressure and covers least distance.

To find out pressure or volume in gasses we have the formula $P_1V_1=P_2V_2$ where “P1” is initial pressure of gas in a fixed volume “V1” and “P2” is final pressure of gas in a different fixed volume “V2”

By this equation we conclude that pressure is inversely proportional to volume which means that if we decrease the volume of gas trapped then pressure increases and vice Versa.

Whenever question asks to find total pressure exerted on an object in specific depth in any liquid and liquid is open in atmosphere then to find final total pressure we have to add atmospheric pressure as well i.e 100,000Pa

Therefore the formula for total pressure exerted on an object in liquid which is open to atmosphere is $pgh+atm$ (atmospheric pressure)



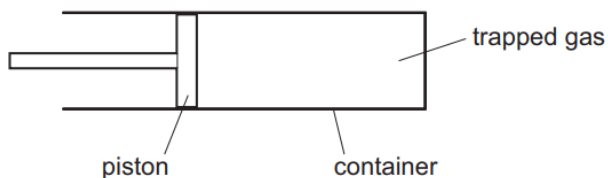
MCQs:

M/J_2024_v21

Gas of volume 200 cm^3 is trapped inside a container by a piston.

The piston is pushed to the right and the volume of the gas decreases to 100 cm^3 .

The temperature of the gas remains constant.

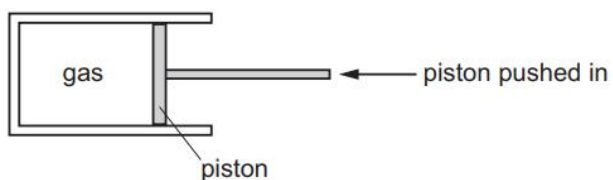


Which row states the effect that this has on the kinetic energy of the gas particles and the force per unit area exerted by the particles colliding with the inside walls of the container?

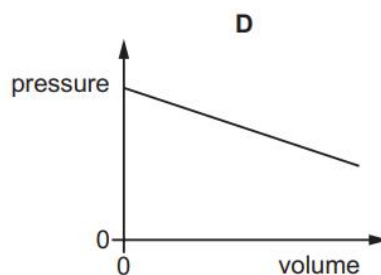
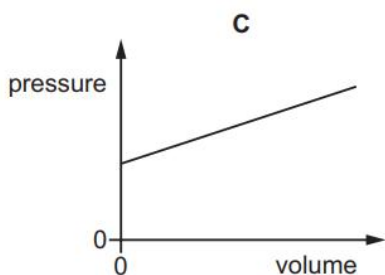
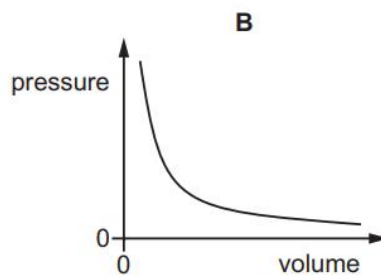
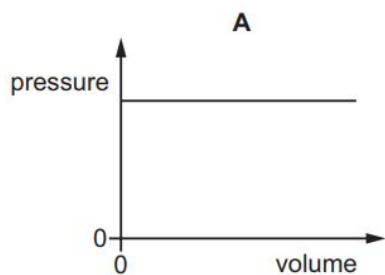
	kinetic energy	force per unit area
A	doubles	doubles
B	doubles	stays the same
C	stays the same	doubles
D	stays the same	stays the same



The diagram shows a quantity of gas trapped in a cylinder. The piston is pushed in slowly and the gas is compressed. The temperature of the gas does **not** change.



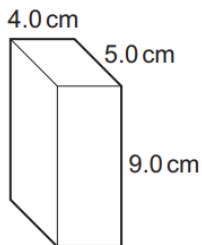
Which graph shows the relationship between the pressure and the volume of the gas?





F/M_2023_v22

The diagram shows a rectangular block of weight 16 N. It is resting on a flat surface.



What is the pressure at the base of the block due to its weight?

- A 0.089 N/cm²
- B 0.36 N/cm²
- C 0.80 N/cm²
- D 320 N/cm²

M/J_2023_v22

The density of sea water is 1030 kg/m³.

The gravitational field strength on the Earth is 9.8 N/kg.

Atmospheric pressure is 101 000 Pa.

At which depth in sea water is the total pressure due to the atmosphere and the water equal to 513 000 Pa?

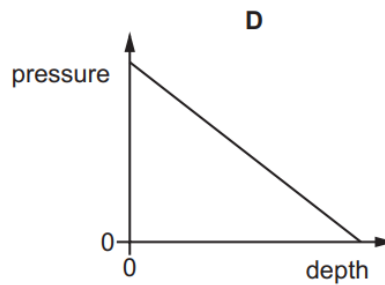
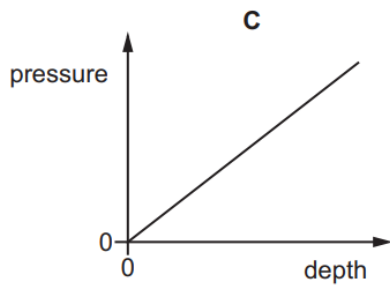
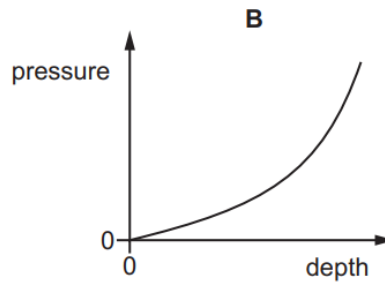
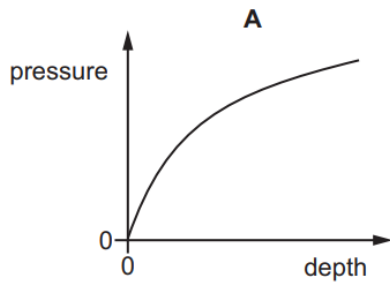
- A 40.8 m
- B 50.8 m
- C 400 m
- D 498 m



The water in a swimming pool exerts a pressure at the bottom of the pool.

Which graph shows the relationship between the pressure exerted by the water and the depth of water in the pool?

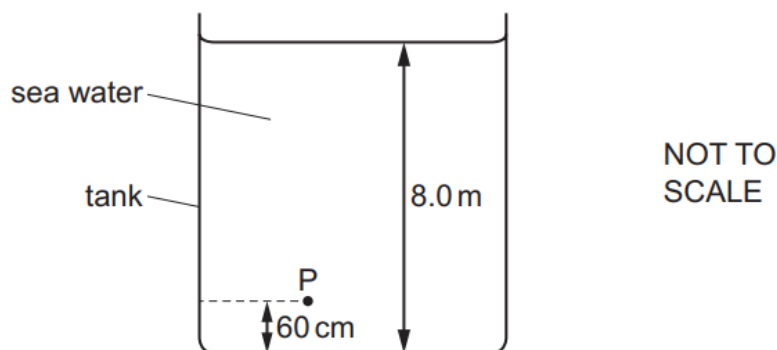
(Assume the density of water is constant.)





O/N_2022_v22

The diagram shows a tank containing sea water.



The density of the sea water is 1020 kg/m^3 .

What is the pressure at point P relative to atmospheric pressure?

- A 7400 Pa above atmospheric pressure
- B 7500 Pa above atmospheric pressure
- C 75 000 Pa above atmospheric pressure
- D 82 000 Pa above atmospheric pressure

O/N_2022_v23

A measuring cylinder of cross-sectional area 4.0 cm^2 contains 224 cm^3 of liquid.

The pressure of the liquid at the base of the measuring cylinder due to the liquid is 8800 Pa.

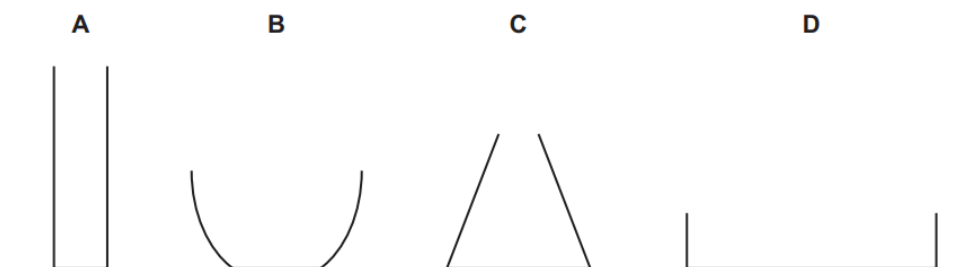
What is the density of the liquid?

- A 224 kg/m^3
- B 385 kg/m^3
- C 1600 kg/m^3
- D 2200 kg/m^3



Four containers are filled to the top with the same liquid. The base of each container is circular.

Which container has the greatest pressure exerted by the liquid at its base?



Answers:

Refer to marking scheme.



Structured:

F/M_2024_v42

- (a) A car has a weight of 13000N. The car is supported by 4 tyres. The area of each tyre in contact with the road is 0.016m^2 .

- (i) Calculate the pressure on the road due to the weight of the car.

pressure = [2]

- (ii) Explain, in terms of particles, why the air pressure in the tyres increases when the car travels along the road.

.....

.....

.....

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- (b) A gas cylinder contains helium gas at a pressure of $2.0 \times 10^6 \text{ Pa}$. A volume of 0.026 m^3 of the compressed gas is released from the cylinder into balloons. Each balloon contains 0.015 m^3 of helium at atmospheric pressure ($1.0 \times 10^5 \text{ Pa}$). The temperature remains constant.

Calculate the maximum number of balloons that can be filled.

maximum number of balloons = [3]

[Total: 9]

M/J_2023_v42

- (a) Fig. 3.1 shows a person moving across an ice-covered pond to reach a ball on the ice.



Fig. 3.1

Explain why this way of moving across the ice is safer than walking. Use your understanding of pressure in your answer.

.....
.....
.....
..... [3]



(b) Fig. 3.2 shows a side view of the pond with a layer of ice floating freely on the water.

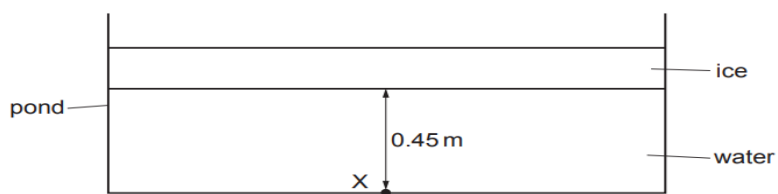


Fig. 3.2

The surface area of the pond is 5.0 m^2 .
The mass of the ice is 690 kg .
The density of water is 1000 kg/m^3 .
Point X is 0.45 m below the ice.

Calculate the pressure at point X due to the ice and the water.

pressure = [4]



Fig. 4.1 shows a bottle part-filled with water. The air inside the bottle is at the same pressure as the air outside the bottle. The bottle and its contents are at room temperature.

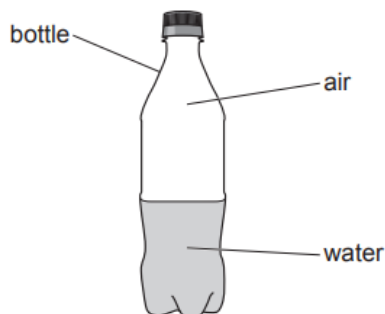


Fig. 4.1

(a) The temperature of the bottle and its contents are increased.

(i) Explain, in terms of particles, how the air pressure inside the bottle changes as the temperature increases.

.....

.....

.....

..... [3]

(ii) The lid is removed from the bottle.

State and explain how the air pressure inside the bottle changes.

statement

explanation

..... [2]



- (c) Another plastic bottle is filled to the top with water. The height of the bottle is 40.0 cm. The density of water is $1.0 \times 10^3 \text{ kg/m}^3$.

Calculate the pressure difference between the top and bottom of the water.

pressure difference = [2]

[Total: 9]



Answers:

(a)(i) Pressure=Force/Area. The force exerted is equal to the weight which is 13000N. The area occupied by a tire is 0.016m^2 and since there are four tires the total area will be $4 \times 0.016 = 0.064\text{m}^2$. Now pressure = $13000/0.064$ so pressure = 203125 Pa or 200000 Pa to 2 sig figs.

(a)(ii) (This question is of four marks). Since the question is of four marks we need to write four points to get full marks.

Firstly, when the car moves along the road instead of standing still, there will be a force of friction on its tires that will oppose its motion.

This force will cause some of the car's kinetic energy to be wasted by changing it to heat energy, which will increase the temperature of the tires and heat them up. A greater temperature of the tires will cause the air particles in the tire to have greater energy so they will move faster.

The air particles will collide more frequently with the walls of the tire and exert a greater force on them.

Since the force exerted on the tires is greater but the area of the tires is constant, the tire pressure will increase.

(b) In this question, since temperature is constant, we can use Boyle's law to find out the new volume of helium gas when its pressure changes.

$$\text{Boyle's Law: } P_1V_1 = P_2V_2$$

$$2.0 \times 10^6 (0.026) = 1.0 \times 10^5 (V_2)$$

$$V_2 = 52000/10^5 = 0.52\text{m}^3$$

New volume of helium gas is 0.52m^3

Volume needed for one balloon to be filled = 0.015m^3

Max number of balloons filled = $0.52/0.015 = 34.6667$

Since only 34 full balloons can be filled, our answer is 34.

2)

Since this question is 3 marks we will need to give 3 valid points.

Pressure is force per unit area OR $P = F/A$

By lying down and spreading out his weight, the person is covering a much greater area of the ground.



Since the downwards force(weight) is constant while the area has increased, the total pressure exerted on the ground is less so the ice is much less likely to break.

(B) Pressure in solids=Force/Area

Pressure in fluid= Density x Gravitational field strength x height below the surface of liquid OR $P=\rho gh$

The pressure on point X will be equal to the sum of the pressure exerted by the ice and the water both because both the ice and the water are exerting pressure at that point.

Pressure on point X= Pressure of ice + Pressure of water

Pressure of ice= Weight/Area of pond

$$P_i = 690 \times 9.81 / 5.0 \quad \therefore P_i = 1353.78 \text{ Pa}$$

$$P_w = 1000 \times 9.81 \times 0.45 \quad \therefore P_w = 4414.5 \text{ Pa}$$

$$\text{Pressure at X} = 1353.78 + 4414.5 = 5768.28 \text{ Pa}$$

$P_x = 5800 \text{ Pa}$ rounded off to two significant figures

(C) Pressure in liquids= $\rho g \Delta h$

Pressure at top=0

$$\text{Pressure at bottom} = 1000 \times 9.81 \times 40/100 = 3900 \text{ Pa}$$

$$\text{Pressure difference} = 3900 - 0 = 3900 \text{ Pa}$$

3)

(a)(i) When the temperature of the bottle and its contents is increased, the air particles inside the bottle gain more kinetic energy. They move faster and have more forceful and frequent collisions. Thus, they exert more force per unit area leading to a greater change in momentum as well.

Since pressure is force per unit area OR rate of change of momentum per unit area, the pressure will increase while the volume remains unchanged.

(a)(ii) When the bottle and its contents were heated, pressure increased and became greater than the outside pressure(atmospheric pressure). So when the lid is removed air particles will move from higher to lower pressure and pressure inside the bottle will decrease.

Statement: *The air pressure will decrease.*

Explanation: *Air will move out of the bottle from higher to lower pressure, until the air pressure inside the bottle is equal to the air pressure outside the bottle.*



UNIT 2.1

Kinetic particle model of matter

The three states of matter ,solids , liquids and gasses have different properties and behave in different ways

Solids have a definite shape and volume and the particles can only vibrate about their fixed space

Liquids have a definite volume but no definite shape . the particles can slide past one another

Gasses have neither definite volumes nor definite shapes , the particles are spaced far apart and can move around freely with minimal intermolecular forces

In a change of state of matter ,only the average kinetic energy of the particles changes , not the amount or mass of particles

The following are the state changes :

Solid to liquid : Melting

Liquid to Solid : Freezing

Liquid to Gas : Evaporation / Boiling

Gas to liquid : Condensation

Solid to Gas : Sublimation

Arrangement of particles

Solids:

Particles are packed closely in a fixed, regular pattern,

Particles can only vibrate about their fixed positions due to strong intermolecular forces.

Density is high because particles occupy a small, fixed space.

Liquids :

Particles are close but arranged randomly, allowing them to slide past one another.

This fluidity allows liquids to change shape based on their container but maintains a fixed volume.



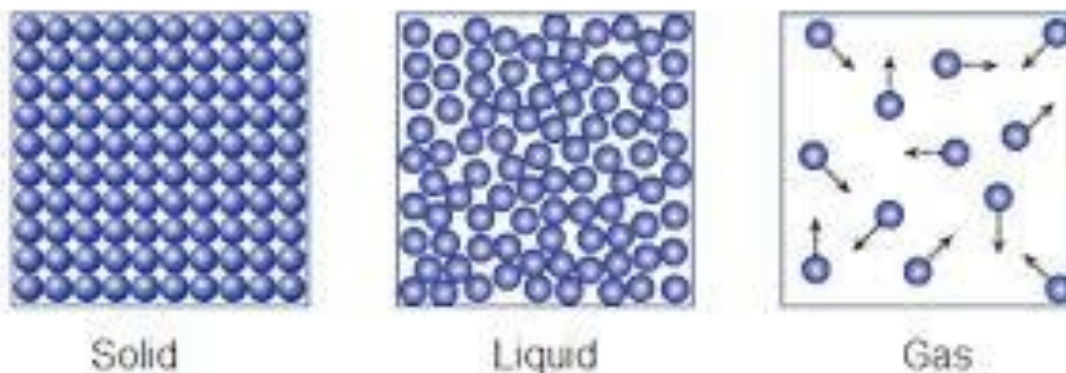
Density is moderate; particles are closer than in gases but not as rigidly packed as in solids.

Gases:

Particles are widely separated, moving freely and randomly in all directions at high speeds.

Low density due to the large space between particles, which allows gases to be compressed easily.

Gases expand to fill the entire volume of their container.



Intermolecular Forces

Solids:

Strong forces hold particles in place, giving solids a fixed volume and shape.

Particles are tightly packed with minimal space between them.

Liquids:

Forces between particles are weaker, allowing limited movement while remaining close

Liquids can flow and adapt shape but retain a constant volume.

Gases:

Negligible intermolecular (London dispersion) forces allow particles to move independently and occupy larger spaces.

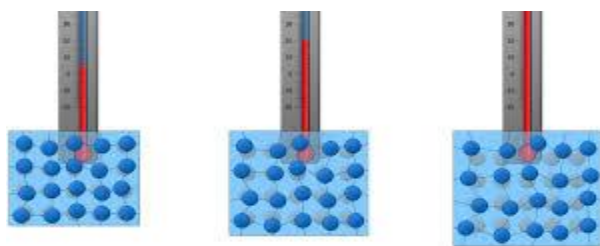
Gases can expand, compress, and flow freely within any container.



Temperature and Energy of Particles

Effect of Temperature on Particle Movement:

Temperature increase increases particle kinetic energy, causing faster movement. In gases, higher temperatures increase particle speed and frequency of collisions, raising pressure (in a closed container). Since pressure is force over area, more force exerted due to more collisions in the same area leads to higher pressure.



Absolute Zero:

The theoretical point (0 Kelvin or 273 °C) where particles would be stationary, representing the lowest possible temperature.

The Conversion rate from Kelvin to Celsius and Vice versa is :

Temp in K = temp in C + 273 (*make C the subject if required to find celsius*)



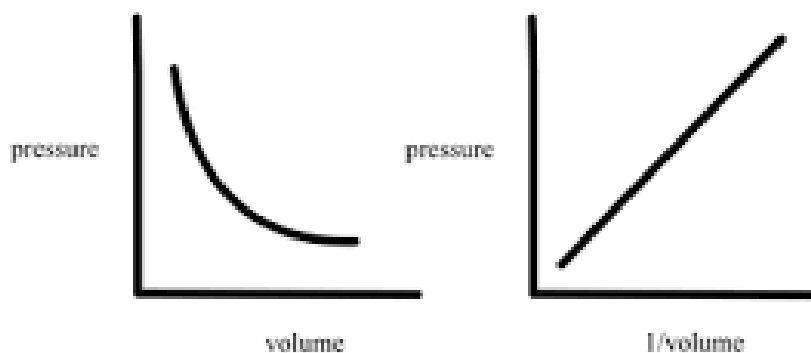
Pressure in Gases and Particle Collisions

Gas particles collide with container walls, exerting force; pressure is this force per unit area. Faster Moving particles (higher temperatures) result in more frequent, forceful collisions, increasing pressure.

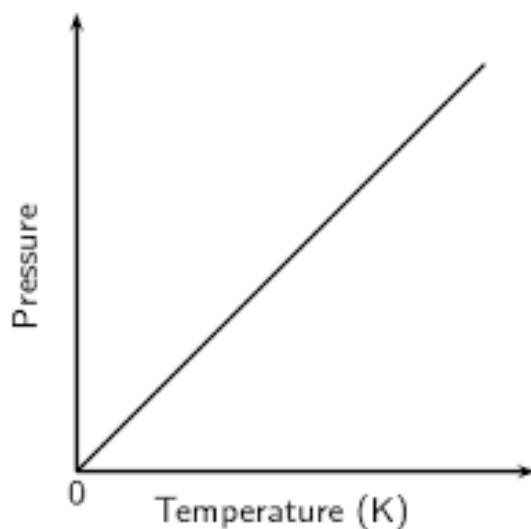
Gas Laws:

PressureVolume Relationship (Boyle's Law): At constant temperature, increasing gas volume reduces pressure, and vice versa. So Pressure is Inversely proportional to volume . An equations formed is :

$$P_1V_1 = P_2V_2$$

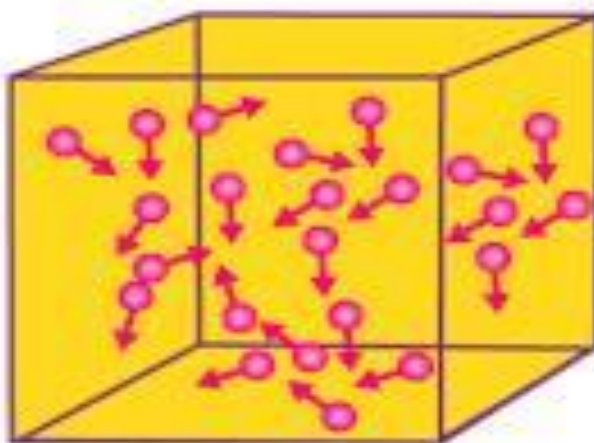


PressureTemperature Relationship (Constant Volume): At fixed volume, higher temperature raises pressure due to more energetic collisions.



Brownian Motion

It is the random, zigzag movement of particles in fluids due to collisions with invisible, fast moving particles like atoms or molecules. It shows us the existence of much smaller particles. For example, pollen compared to air molecules. The fast moving air molecules collide with the pollen molecules and cause this random motion .



Brownian Movement



Practice Questions (Solved)

Q1. A sealed gas container has a fixed volume. Explain why the pressure of the gas inside the container increases when it is heated.

Ans) In a gas, particles move randomly and collide with each other and the walls of the container. The pressure of a gas is caused by the force of these collisions against the container walls per unit area.

When the temperature of the gas is increased, the particles gain kinetic energy, which causes them to move faster. Faster moving particles collide with the walls more frequently and with greater force. Since the container has a fixed volume, the number of particles remains constant, but the increased frequency and force of collisions lead to a higher pressure

Q2. Explain why a gas can be compressed more easily than a liquid or a solid.

Ans) In a gas, particles are widely spaced apart and have negligible intermolecular forces, allowing them to move freely and fill the entire volume of a container. Because there is a lot of empty space between gas particles, they can be brought closer together, making gases highly compressible.

Practice Questions (Unsolved)

P4

1. Explain why solids have a definite shape and volume, while liquids have a definite volume but no definite shape. What allows gases to have neither a definite shape nor volume?
2. Describe the changes in particle arrangement and energy when a solid is heated until it becomes a liquid, then further heated until it becomes a gas. Include details on the role of intermolecular forces in each state.
3. A balloon is filled with gas at room temperature. Predict what would happen to the size of the balloon if it were placed in a freezer, assuming the balloon is flexible.



P2 :

1. Which of the following is a characteristic of particles in a solid?
 - A) Particles move freely and quickly
 - B) Particles are arranged randomly
 - C) Particles vibrate in fixed positions
 - D) Particles are far apart from each other
2. When a liquid evaporates, what happens to its particles?
 - A) They move closer together
 - B) They gain energy and move faster
 - C) They lose energy and slow down
 - D) They form a fixed pattern
3. Which of the following changes occurs when a solid turns into a liquid?
 - A) The particles move closer together
 - B) The intermolecular forces become stronger
 - C) The particles gain energy and slide past each other
 - D) The particles move very far apart and become randomly arranged
4. In a gas, which factor directly affects the pressure it exerts on the walls of its container?
 - A) The size of the container only
 - B) The shape of the container only
 - C) The speed and frequency of particle collisions
 - D) The color of the gas particles
5. A balloon is left in a warm room, causing it to expand. What happens to the pressure inside the balloon as it expands?
 - A) It increases because the particles move closer together
 - B) It decreases because there is less space for collisions
 - C) It remains constant due to constant particle speed
 - D) It decreases because particles have more space to spread out
6. What will happen to the volume of a fixed mass of gas if both its temperature and pressure are increased?
 - A) It will increase
 - B) It will decrease



- C) It will remain constant
 - D) It cannot be determined without additional information
7. Which of the following explains why gases are much easier to compress than liquids?
- A) Gas particles are heavier than liquid particles
 - B) Gas particles are closer together than liquid particles
 - C) Gas particles have much more space between them than liquid particles
 - D) Liquid particles move more freely than gas particles
8. According to Boyle's Law, if the pressure of a gas is increased while its temperature remains constant, what happens to its volume?
- A) It doubles
 - B) It remains constant
 - C) It decreases
 - D) It depends on the type of gas use



Answers :

1. C
2. B
3. C
4. C
5. D
6. D
7. C
8. C

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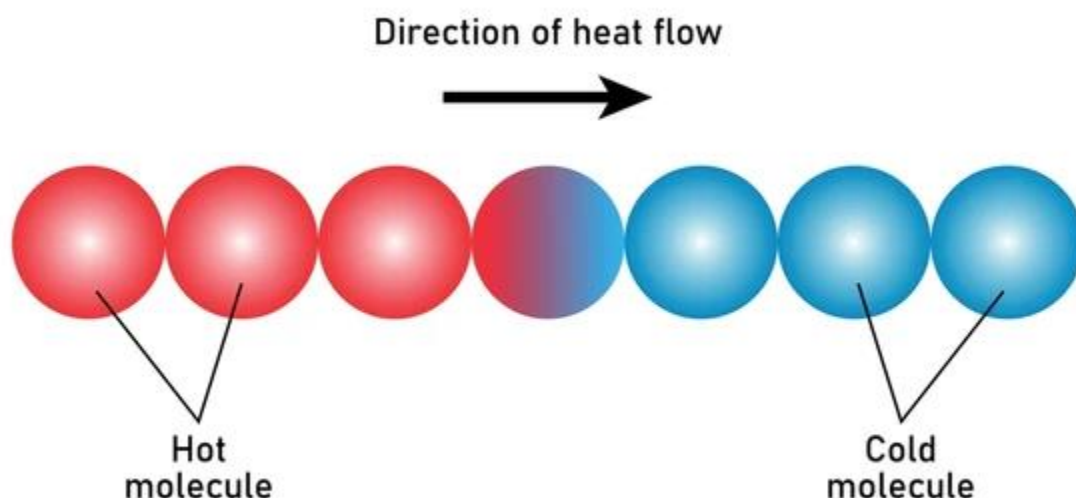


UNIT 2.2 -2.3 Thermal Physics

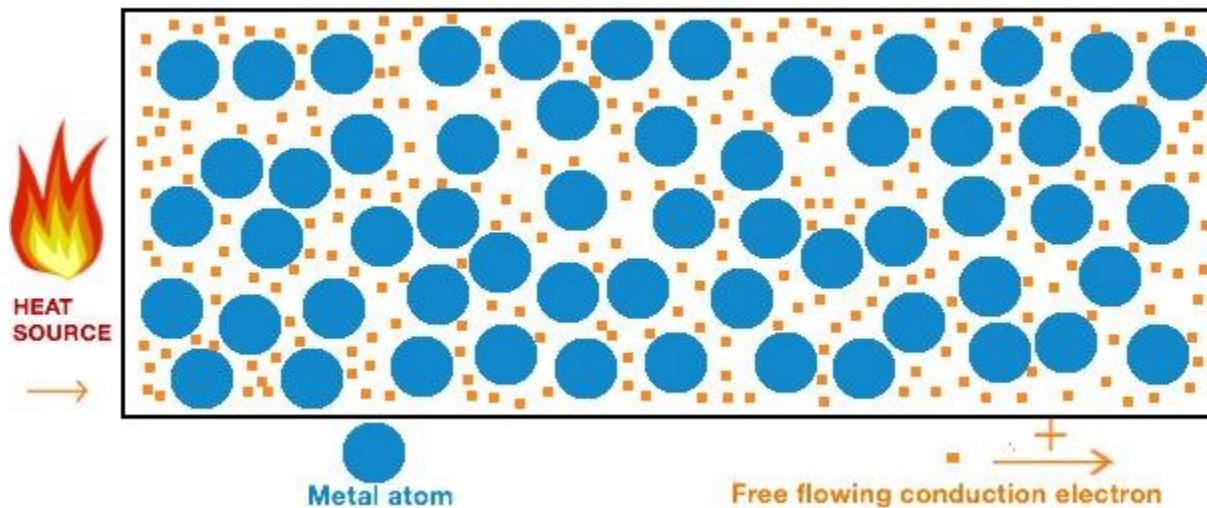
Conduction: Process in which heat energy transfers without the movement of medium. For example in copper and Aluminium etc.

Conductor: Material that contains free moving electrons. For example copper and other metals.

Insulator: Material that does not contain any free moving electrons. For example rubber, plastic, and glass.



As shown in the above image, when heat is provided to one part of a solid, then the particles in it start to collide vigorously with each other. This is the process by which heat reaches from hot molecule to cold molecule as they transfer energy to cold particles. Gradually all of the solid gets heated thus we can conclude that heat moves from high temperature region to low temperature region.



As shown in the above image, thermal conduction also occurs due to free moving electrons in metals whereas in glass thermal conduction is slow due to no free moving electrons.

Conduction in gases and liquids:

Gases and liquids are poor conductors of heat because the particles in these states of matter are spread out and move around easily, making it difficult for vibrations to pass from one particle to another.

The particles in liquids are close together but can slide past each other. The weaker intermolecular forces and more space between the particles make it harder to transmit vibrations.

The particles in gases are widely spread apart, so they don't "nudge" each other when they vibrate. The particles in gases have even more space than in liquids, so they collide infrequently.

In contrast, solids are better conductors of heat because the particles are closely packed together, allowing vibrations to easily transfer from one particle to the next.

Examples of bad conductors:

Handles of all cooking materials

Sheet of thermocol

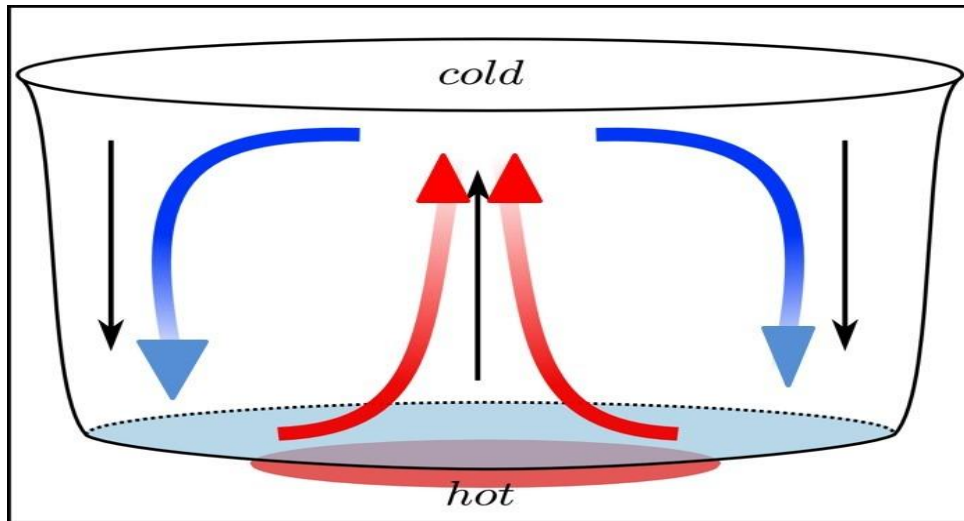
Fiber



Carpet, wooden floor

Convection:

Process in which heat energy transfers with the movement of medium (liquid and gas). It does not occur in solids.



As shown in the above diagram, during convection, when particles of liquids or gasses are heated then convectional currents form. In convectional current particles with high temperature rise due to less density and cold particles come down due to higher density. Throughout this process, each and every part of a liquid or gas is heated.

NOTE: BOTH CONDUCTION AND CONVECTION REQUIRE MEDIUM.

Radiation: Process in which heat energy transfers without the aid of any medium. For example, heat from the sun travels through space.



Factors affecting the rate of Radiations:

Surface Area: More the surface area, high is the rate of absorption of heat.

Surrounding Temperature: High is the surrounding temperature, more is the rate of absorption of heat. Heat travels from high temperature to low temperature and its speed depends on the difference in temperature. When the temperature difference is more, the rate of heat transfer will be more and vice versa.

Colour:

Dull black surfaces are good absorbers and emitters of heat while silver shiny surfaces are bad absorbers and emitters of heat; therefore, when we need to maintain an object's temperature and prevent it from absorbing heat from surrounding then we coat it by silver as radiations reflect on the surface. On the other hand when we need to heat up a thing quickly we coat it with dull black as it absorbs and emits heat quickly.



Unit 3: Waves and their properties

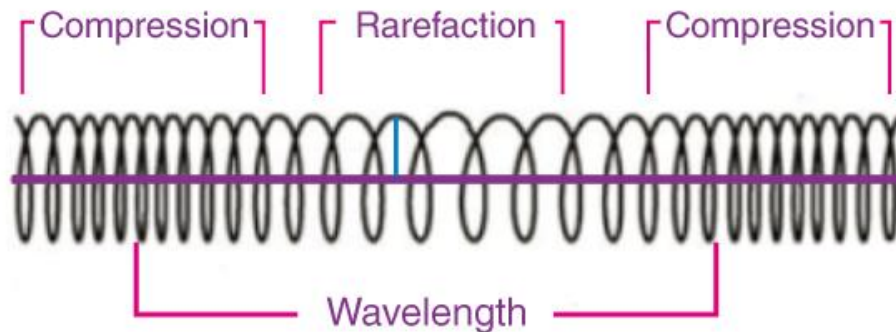
Waves:

It is the mode of transfer of energy caused by oscillatory or vibratory motion of the particles of the medium. Waves transfer energy without the transfer of matter i.e particles. Examples of waves are rope waves, water waves, and light waves.

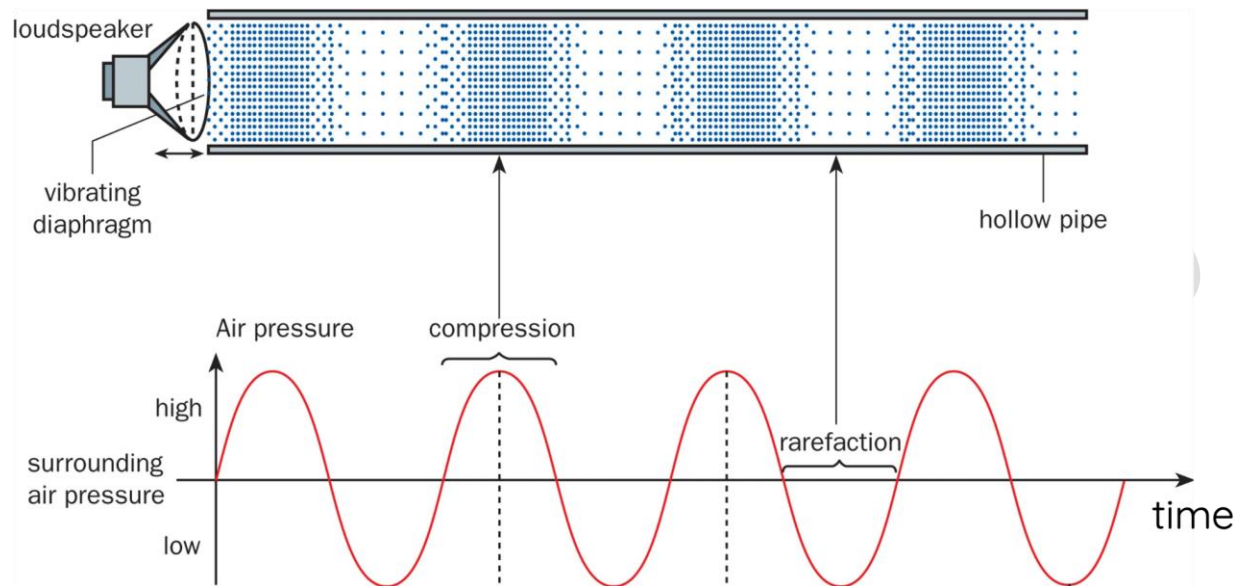
Types of waves:

There are two types of waves: Longitudinal waves and Transverse waves.

Longitudinal Waves: The waves in which the particles of the medium vibrate parallel to the direction of the transfer of energy or waves. These waves require a medium to transfer energy. An example is Sound waves.



In the above example we can see a slinky spring which shows us how energy is transferred by longitudinal waves. Some particles move close to each other—this is compression, whereas some particles move far from each other—this is rarefaction.

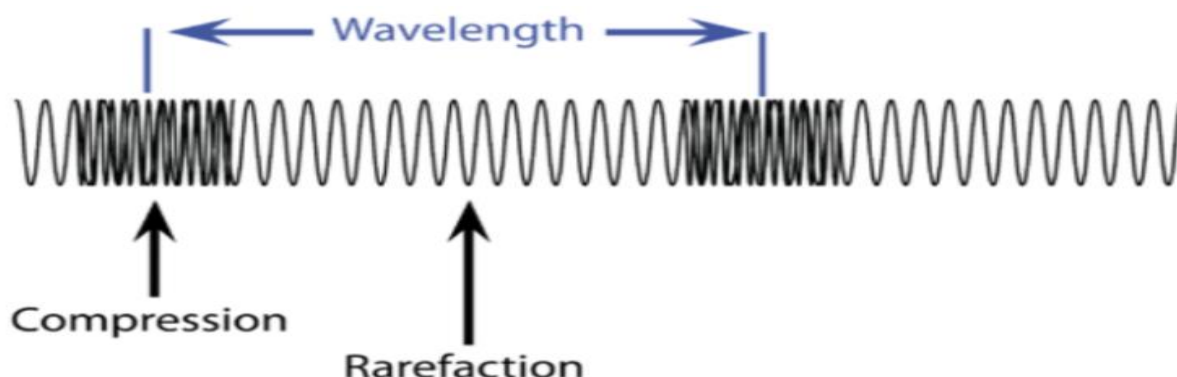


In the above example we can see that when sound energy is transferred it initially causes the particles to move close to each other to produce an area of compression and energy is transferred from particle to particle. Next, the energy moves forward causing the particles to go back to their mean position and thus it causes rarefaction.

Compression: Position in which particles are very close to each other and thus pressure increases. Above graph shows how pressure changes due to compression and rarefaction in particles.

Rarefaction: Position in which particles are far apart thus pressure decreases.

Wavelength: It is the distance between any two consecutive rarefactions or any two consecutive compressions.



Calculating speed of waves:

It is distance covered by a wave per unit time and its formula is $v = d/t$ where “v” is speed in meters/second, “d” is distance in meters and “t” is time in seconds. It can also be transformed into $v = \lambda/t$ where “ λ ” is the wavelength of a wave.

Frequency of waves: It is the number of complete waves produced in one second or number of waves passing through a point in one second.

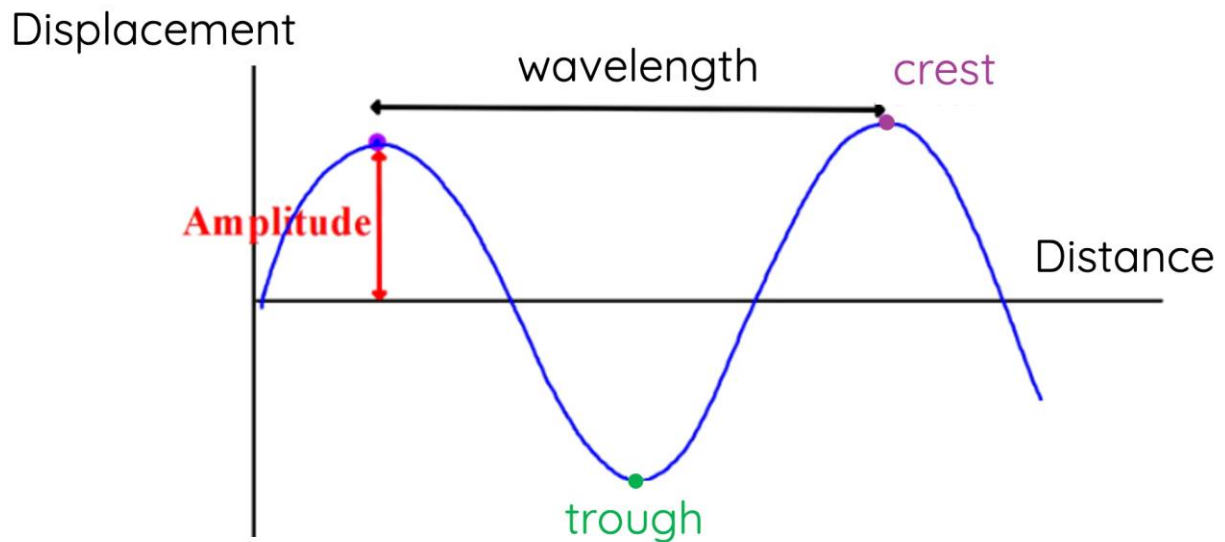
Time period: Time taken for one complete wave to produce. It is inversely proportional to frequency thus we can say that $f = 1/t$ or $t = 1/f$. Therefore, we can transform the formula of speed to $s = f\lambda$.

Transverse waves: Waves in which particles move perpendicular to the direction of wave motion. For example electromagnetic waves, water waves. These waves do not require a medium to travel.

Properties of transverse waves:

Crest: The highest position reached by a particle of the medium in a transverse wave.

Trough: The lowest position reached by a particle of the medium in a transverse wave.



Wavelength: Distance between two consecutive crests or distance between two consecutive troughs.

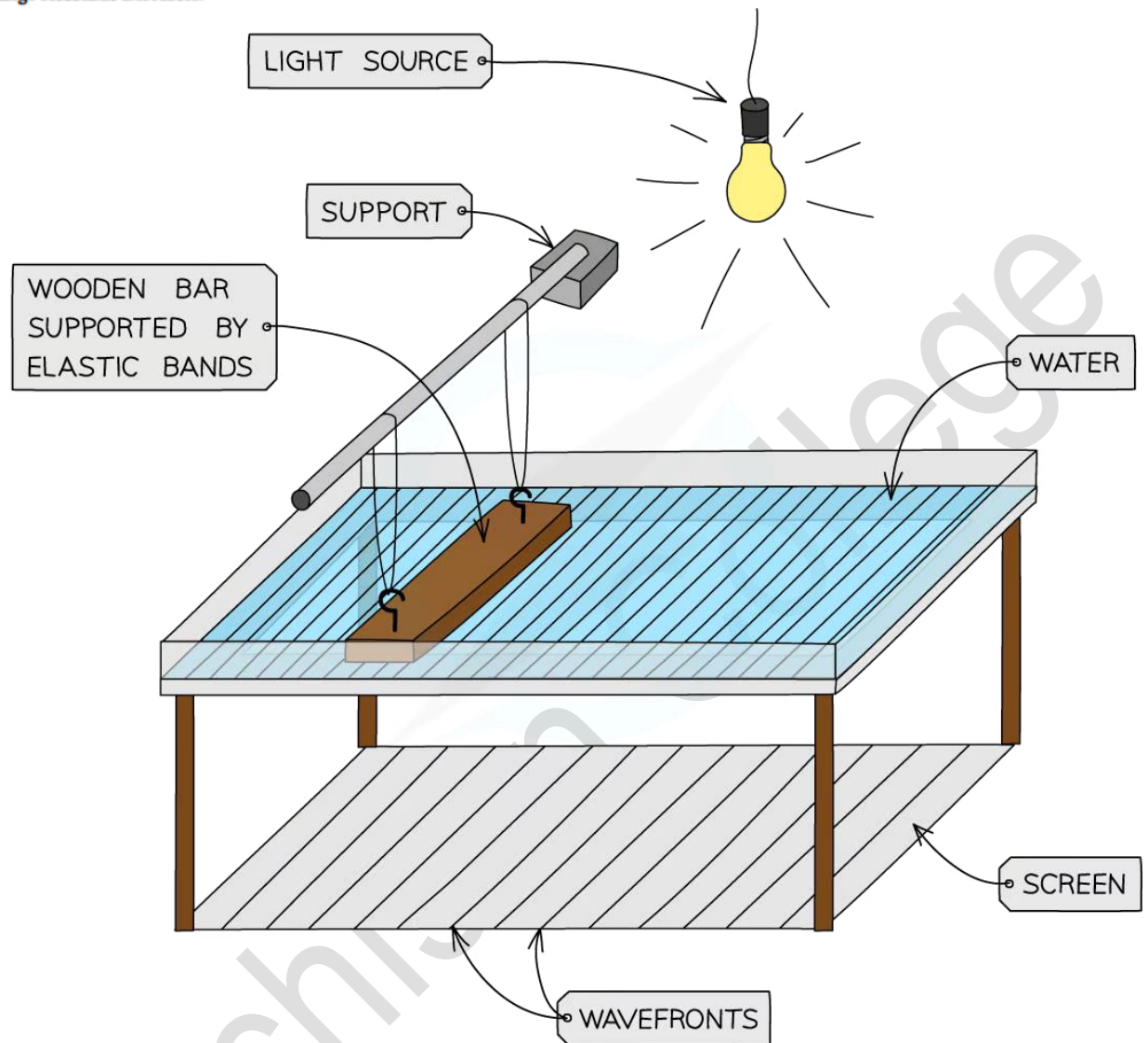
Amplitude: Maximum displacement of the particle from the mean position.

Note: Method of calculating speed, frequency, and time period is the same.

Wave front: It is a line joining two inphase particles.

Phase: In wave motion, the particles showing exactly the same motion/ movement are called in phase.

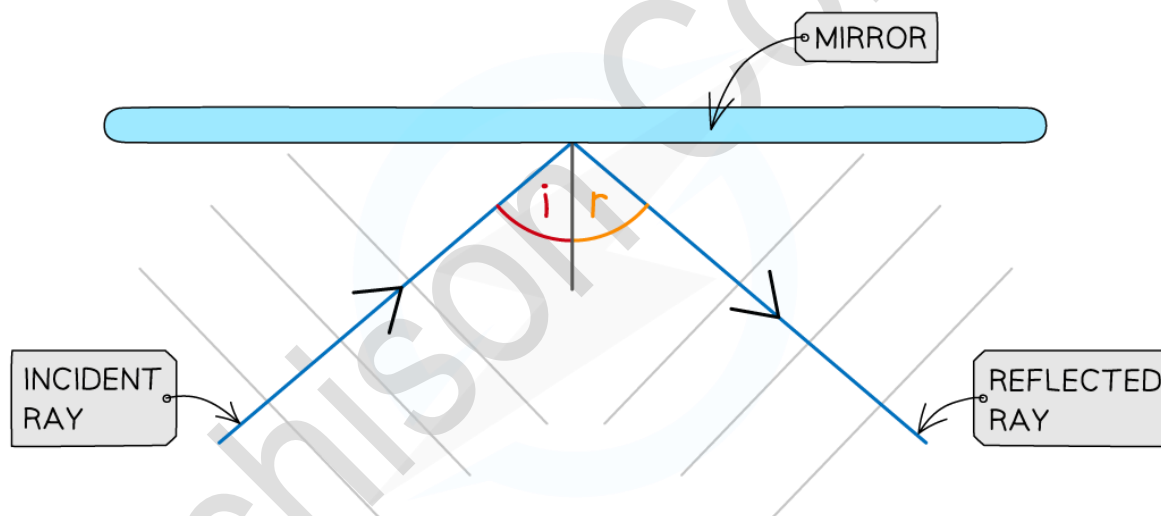
Water waves in a Ripple Tank





As shown in the above diagram, In the Ripple tank there is a source to produce waves in the tank which over here is a wooden bar supported by elastic bands so that it can move up and down and produce waves. Beneath the Ripple tank there is a screen which shows wave fronts of the waves produced in the ripple tank by source. A light source, which over here is a bulb, help Wavefronts to form on the screen and make it easy for us to view them. The distance between two Wavefronts is constant and it is wavelength.

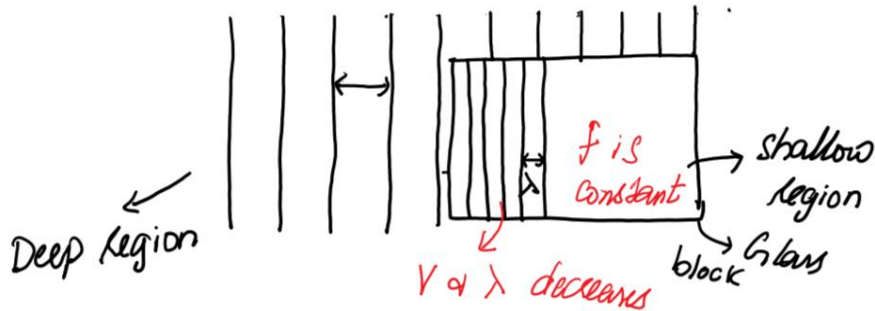
Reflection of waves in a Ripple tank:



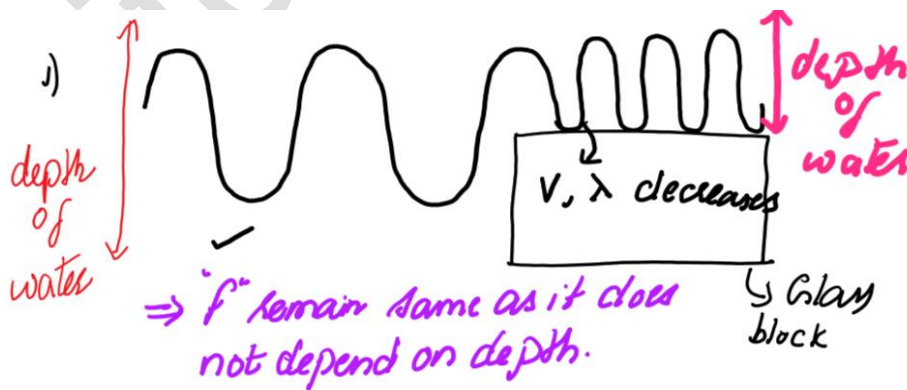
As shown in the above example, the wavefronts are perpendicular to the incident line which is showing direction of motion. It hits the surface of a mirror and reflects back. The direction of motion changes but the wavelength remains the same and wavefronts are perpendicular to the direction of motion. From normal, Angle of incidence and Angle of reflection

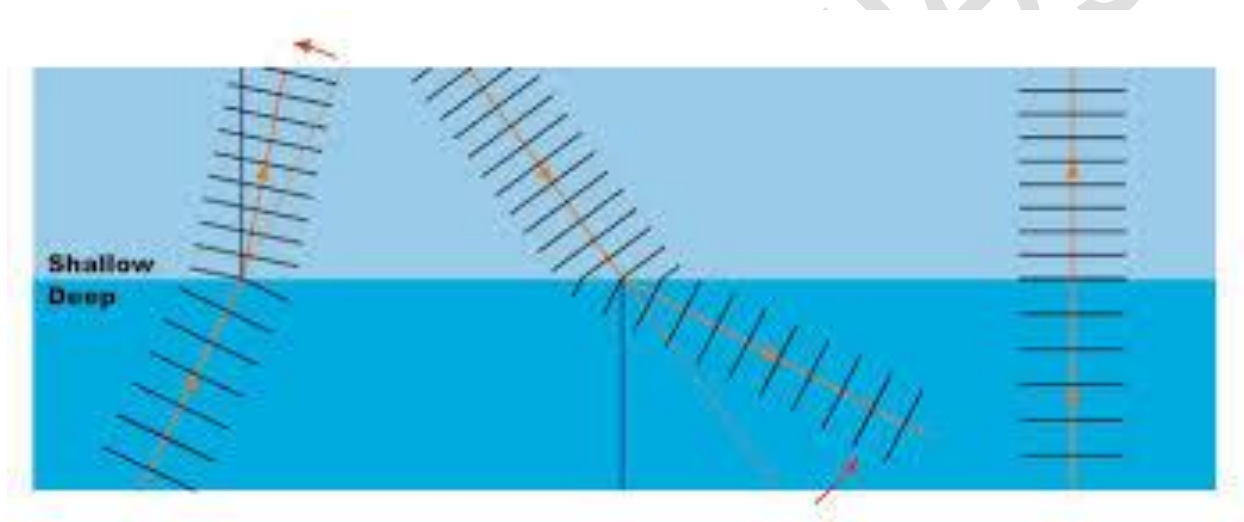


are the same.



As Shown in above diagrams, when depth changes, it affects the waves, Frequency remains the same as it is depending on the source which is producing waves, but either speed or wavelength of the waves decrease.





As shown in the above diagram, waves change their direction or “Refract” due to change in density or change in a medium.

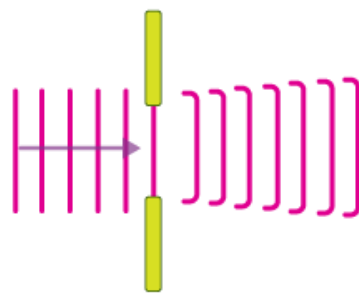
When waves move from Deep water to shallow water then Wavelength decreases (refer to the diagram), but frequency remains the same. The speed also changes due to change in medium and density so the waves slow down.

When waves move from Shallow water to deep water then Wavelength increases and speed increases so they bend away from normal. Frequency is the same.

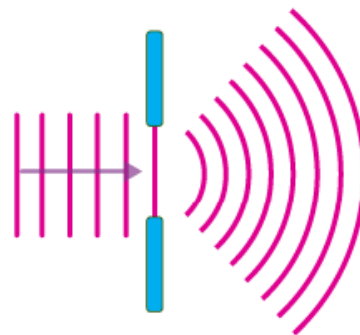
When Waves change medium but their direction of motion is perpendicular to the surface then no refraction occurs. In all cases wavefronts are perpendicular to direction of motion.



Diffraction of Waves:

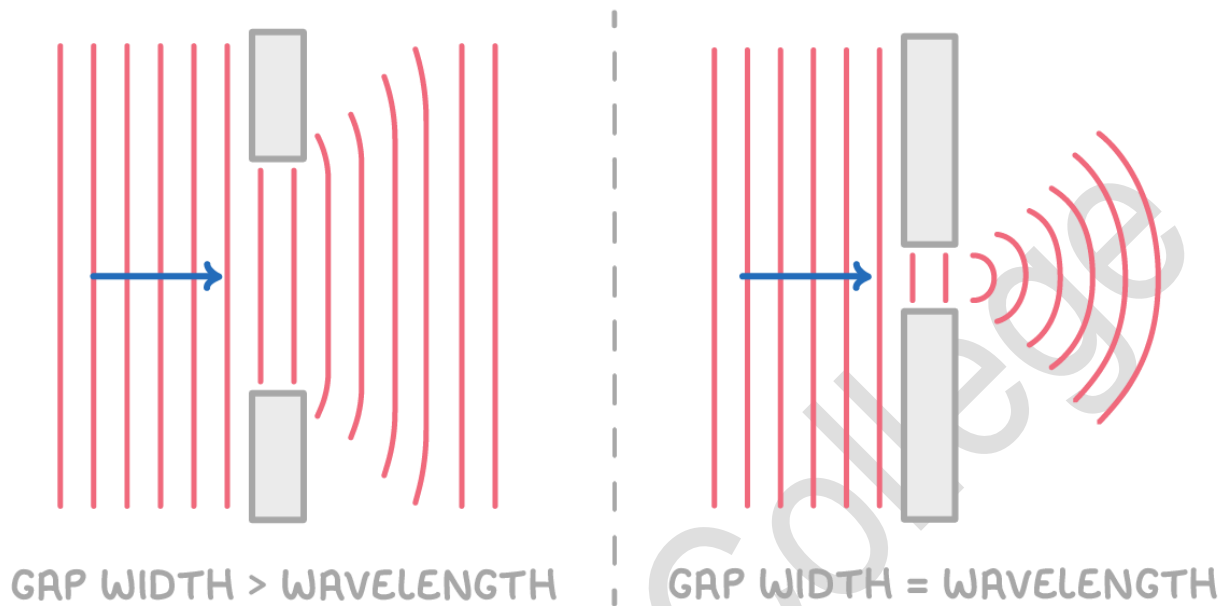


Wide gap
Small diffraction effect



Narrow gap
Large diffraction effect

When Waves pass through a wide gap or a narrow gap then its wavefronts change their shape as shown in the above diagram. When the gap width is larger than the wavelength, the wave passes through the gap and does not spread out much on the other side. When the gap size is smaller than the wavelength or equal to wavelength, more diffraction occurs and the waves spread out greatly – the wavefronts are almost semicircular.



Seismic Waves:

Earthquakes are caused by sudden rock movement underground. The vibrations send “Seismic Waves” (Shock Waves) through the Earth. These waves get weaker as they travel through the ground.

Types of Seismic Waves:

P-Waves (Primary waves): These are longitudinal waves. They are the fastest and arrive first. They travel through solids and liquids deep in the earth at a speed of several Kilometers per second. Their speed is highest through Solids.

S-Waves (Secondary waves): They are transverse waves. They arrive after the primary waves because they are slower. They can pass through solids deep in the Earth, but not through liquids such as melted rocks.



UNIT 4: MAGNETISM AND ELECTRICITY

Simple phenomena of magnetism

Magnetic forces are due to interactions between magnetic fields. In a magnet, like poles repel and opposite poles attract.

- Magnetic materials are materials that are attracted to magnets and can be magnetized (e.g. iron, steel, cobalt, nickel)
- Non-magnetic materials are materials that are not attracted to magnets and cannot be magnetized (e.g. glass, plastic)

Induced magnetism:

- Magnetic materials can be magnetized by induced magnetism:
 - They can be magnetized by stroking them with a magnet, hammering them in a magnetic field, or putting them inside a coil with a direct current through it.
 - They can be demagnetised by hammering them, heating them or putting them inside a coil with an alternating current through it.
- Magnetic materials that can be permanently magnetized are described as magnetically hard (e.g. steel). Magnetic materials that are only temporarily magnetized are described as magnetically soft (e.g. soft iron).

Permanent magnets vs electromagnets:

- Permanent magnets are a hard-magnetic material that has been permanently magnetized
whereas electromagnets consist of a coil of wire wrapped around a magnetically soft core and can be turned on and off.
- Permanent magnets are more useful when they do not need to be turned off such as a fridge magnet, whereas electromagnets have the ability to be turned on and off so they can be used for situations such as moving scrap metal.

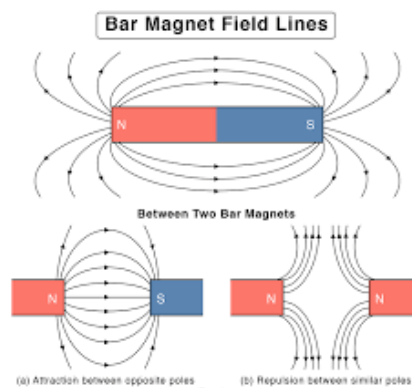
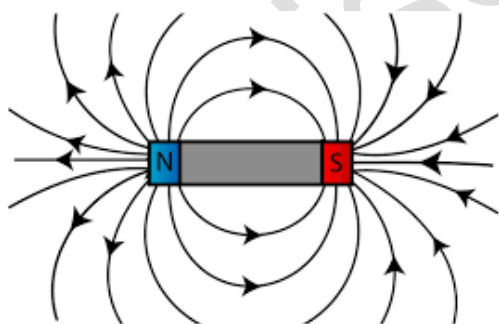


Hard Magnetic Material(e.g steel)	Soft Magnetic Material(e.g iron)
Difficult to magnetize and demagnetise	Easy to magnetize and demagnetise
Retains magnetism well	Loses it magnetism easily

Magnetic fields:

Magnetic field is a region of space around a magnet in which a magnetic pole experiences a force.

- Field lines around a bar magnet point from north to south
- The direction of a magnetic field line shows the direction of the force on a north pole at that point. It goes out of the north pole and into the south pole.
- Field strength decreases with distance from the magnet
- Plotting compasses are small compasses which show the direction and shape of a magnetic field.



What is Electric Charge?

Charge is measured in coulombs. There are positive and negative charges. Like charges repel unlike charges attract.

Charging a body involves addition or removal of electrons

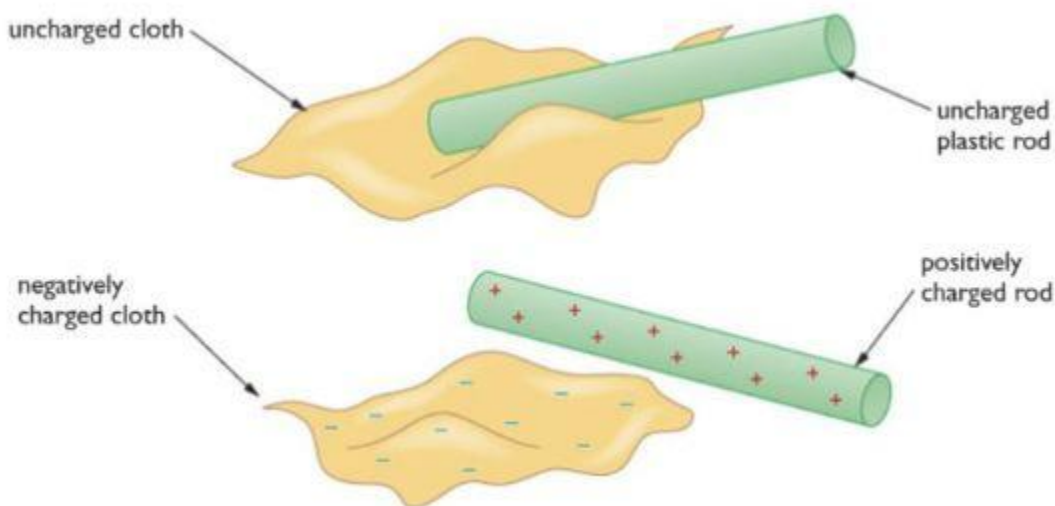
An object becomes positively charged when it loses electrons and negatively charged when it gains electrons.

Conductors allow electrons to flow through them whereas insulators impede the flow of electrons.



Conductors such as metals are used as wires in circuits.

When two insulators are rubbed together, electrons move from one to the other and they become charged. For example, when a rod is rubbed with a cloth, electrons are transferred from the rod onto the cloth and the rod becomes positively charged. This only involves transfer of electrons.



Simple experiment to detect electric charge using gold leaf electroscope:

If a positively charged rod is brought close to the disc on top of the electroscope, electrons are attracted to the top of the disc away from the bottom of the metal stem and gold leaf. The gold leaf will then be repelled from the metal stem because they become positively charged.

Charging by induction:

Induction charging is a charging method in which a neutral object is charged without actually touching another charged object. The charged particle is held near a neutral or uncharged conductive material that is grounded on a neutrally charged material. When a charge flows between two objects, the uncharged conductive material develops a charge with the polarity opposite that of the charged object.



Electric fields:

Electric fields are regions of space around which an electric charge experiences a force

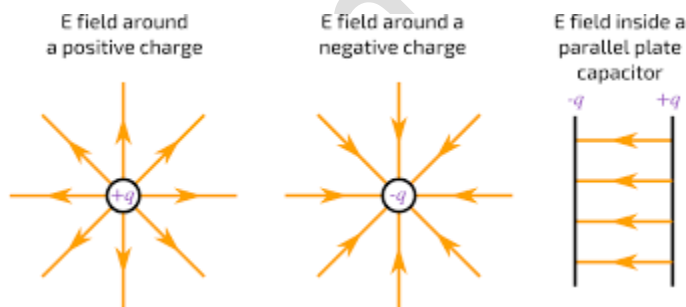
The direction of an electric field at a point is the direction of the force on a positive charge at that point.

Drawing electric fields:

Electric field lines point away from positive charges and towards negative charges.

The field lines around a charged conducting sphere are as if the charge was concentrated at the center of the sphere.

The field lines between two charged plates go in straight lines from the positive plate to the negative plate and are equally spaced apart.



Current:

Current I is measured in amps and is the rate of flow of charge at a point in the circuit.

- The current is given by $I = Q/t$.
- It is measured with an ammeter placed in series.
- In metals, current is due to a flow of electrons.

Conventional current is the rate of flow of positive charge from positive terminal to negative terminal.

Electrons Flow is the flow of negative charge (electrons) from negative terminal to positive terminal.



Electromotive force:

The electromotive force (e.m.f) of an electrical source of energy is measured in volts and is the energy supplied by the source per unit charge in driving the charge round a complete circuit.

Formula: work done on charge/charge(J/Q)

$$V = J/Q$$

Potential difference:

Potential difference V is measured in volts ($1 \text{ V} = 1 \text{ JC}^{-1}$) and is the work done per unit charge in moving between two points in a circuit or through a component.

- It is measured with a voltmeter placed in parallel across the component.
- The higher the potential difference, the greater the current

Formula: work done by charge/charge

$$V = J/Q$$

Resistance:

The resistance of a component is the ratio of the potential difference through a component and current flowing through it. It is measured in ohms. The greater the resistance, the harder it is for current to flow through the component.

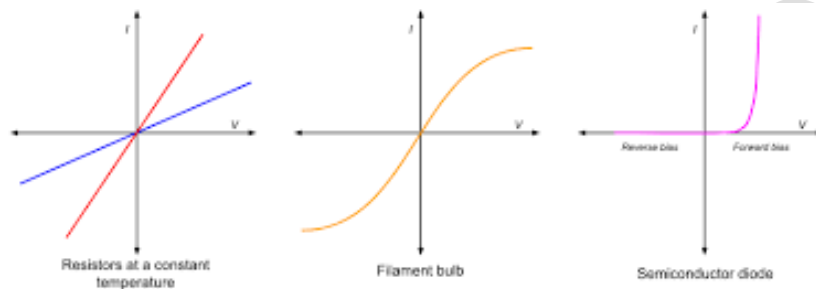
- As the length of a resistor increases, the resistance increases. The resistance is directly proportional to the length.
- As the diameter of a resistor increases, the resistance decreases. The resistance is inversely proportional to the cross-sectional area.

Formula: potential difference/current

$$R = V/I$$



In an ohmic conductor, the current is directly proportional to the voltage (i.e. it has constant resistance). In a non-ohmic conductor (such as a filament lamp), the resistance changes as the voltage and current change.



As the current increases through a filament lamp, so does the temperature. This means electrons and ions vibrate more and collide more, increasing resistance.

NOTE: All these formulas can be rearranged depending on what the question is asking



Electric circuits:

Series

- Components are connected end to end in one loop
- The same current flows through every component
- The potential difference is shared across each component (i.e. the sum of the p.d.s across the components are equal to the total p.d. across the supply).
- The total resistance is the sum of the resistances of each component $R_T = R_1 + R_2$
- The combined e.m.f. of several sources in series is the sum of the individual e.m.f.s

Parallel

- Components are connected to the power supply in separate branches
- The current is shared between each branch (i.e. the sum of the currents in the separate branches is equal to the current through the source)
- The potential difference is the same across every branch
- The total resistance of two resistors in parallel is less than the resistance of either resistor by itself, and is given by $R_1 R_2 / R_1 + R_2$

Advantages of parallel circuits:

If one component breaks, current can still pass through the rest.

Components of Circuits:

A potential divider circuit consists of two resistors connected in series to obtain a smaller voltage than supplied.

The voltage across a certain component is given by $V_{out} = V_{in} \times R / R_T$ where V_{in} is the source voltage, R is the resistance of the component and R_T is the total resistance.



A thermistor is a resistor whose resistance decreases as the temperature increases.

A light dependent resistor is a resistor whose resistance decreases as light intensity increases.

A relay is an electromagnetically operated switch. When a small current passes through the electromagnet, it switches on and attracts an iron arm. This arm rotates about a pivot and pushes the contacts in another circuit together. They are used to switch on a circuit with a high current using a circuit with a small current

A diode allows current to flow in one direction only, because it has a very high resistance in the other direction. They can be used as a rectifier (i.e. convert AC into DC).

Dangers of electricity:

Hazards:

- Damaged insulation – contact with the wire due to gaps in the insulation can cause an electric shock or pose a fire hazard by creating a short circuit.
- Overheating of cables – high currents passing through thin wire conductors cause the wires to heat up to very high temperatures which could melt the insulation and cause a fire.
- Damp conditions – water can conduct a current so wet electrical equipment can cause an electric shock.

Fuses:

- A fuse is a thin piece of wire which overheats and melts if the current is too high, protecting



the circuit.

- Fuses have a current rating which should be slightly higher than the current used by the device in the circuit. The most common are 3A, 5A and 13A.

Circuit breakers:

- Circuit breakers consist of an automatic electromagnet switch which breaks the circuit if the current rises over a certain value.
- This is better than a fuse as it can be reset and used again, and they operate faster.

Earthing metal cases:

- Earth wires creates a safe route for current to flow through in the case of a short circuit, preventing electric shocks.
- Earth wires have a very low resistance so a strong current surges through them which breaks the fuse and disconnects the appliance.



ELECTRICITY SYMBOL TABLE

ELECTRICAL SYMBOLS

CELL		SWITCH	
BATTERY OF CELLS		EARTH OR GROUND	
	OR	JUNCTION OF CONDUCTORS	
		LAMP	
POWER SUPPLY		MOTOR	
D. C. POWER SUPPLY		GENERATOR	
A. C. POWER SUPPLY		AMMETER	
FIXED RESISTOR		VOLTMETER	
VARIABLE RESISTOR		DIODE	
THERMISTOR		LIGHT-EMITTING DIODE	
LIGHT-DEPENDENT RESISTOR		FUSE	
HEATER		RELAY COIL	
POTENTIAL DIVIDER		ELECTRIC BELL	
TRANSFORMER			
MAGNETISING COIL			

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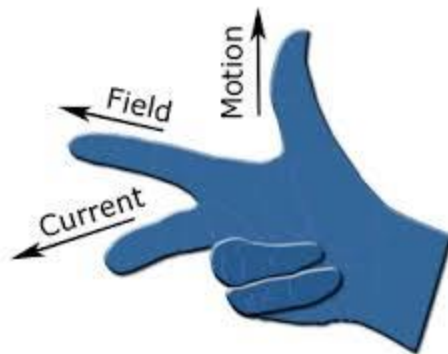
Electromagnetic induction

An electromotive force(emf) induced in a charged conductor when there is relative movement between conductor and magnetic field. For example if a conducting wire moves across a magnetic field, a voltage will be induced in it. If it is part of a complete circuit then a current will flow. This is called the generator effect.

The induced emf can be increased by;
Moving the wire more quickly
Use a stronger magnetic field
Increasing number of turns of the wire

A voltage is also induced in a coil with a changing magnetic field through it. For example when a magnet is moved into the coil, a voltage is induced in it. The more quickly the field lines change the greater the voltage.

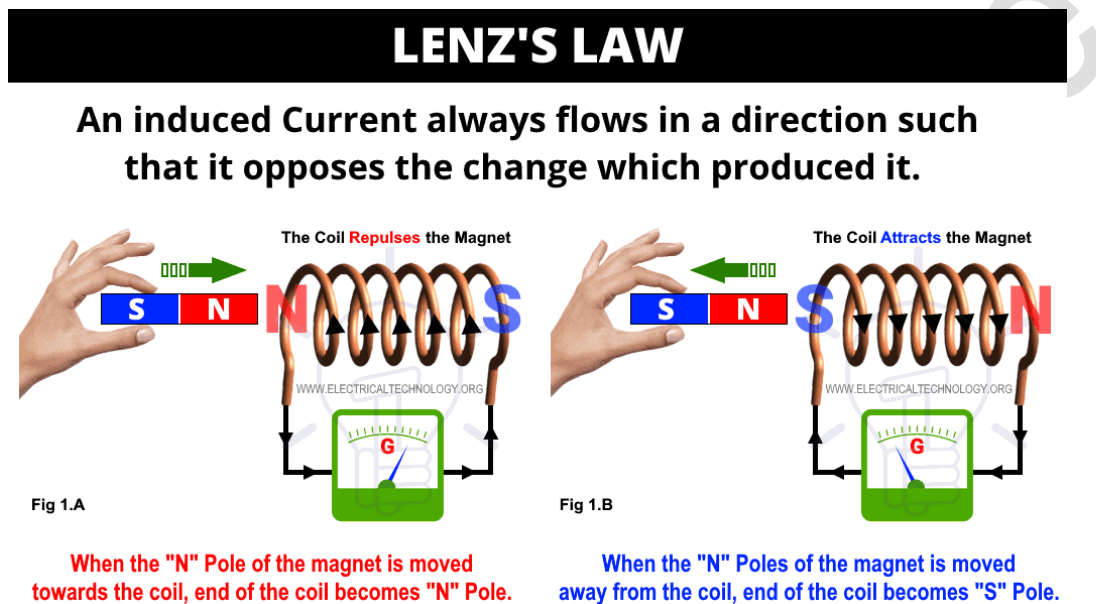
The direction of induced emf is determined by Fleming's right hand rule as shown.





Lenz's Law:

The induced current flows in such a direction that it opposes the change producing it.



Concept of Magnetic flux and Faraday's Law of Flux:

Magnetic flux is the number of magnetic field lines passing through a point in a closed surface. The rate of change in magnetic flux causes induced emf.

Faraday's Law of electromagnetic induction : The rate of change in magnetic flux is directly proportional to emf induced. The greater the change in flux the larger the emf that is induced.

Electricity can be generated by rotating a magnetic within a coil or by rotating a coil in a magnetic field. As they rotate, the magnetic field through the coil changes, which induces a voltage and therefore a current in the coil. The voltage can be increased by:

Using a wire with larger surface area and more turns

Using stronger magnet



Increasing the speed of rotation

An electric current passing through a conductor produces a magnetic field around it. An electromagnet is a coil of wire wrapped around a solenoid with a soft iron core that acts as a magnet when current flows through it and can be turned on and off.

AC generator

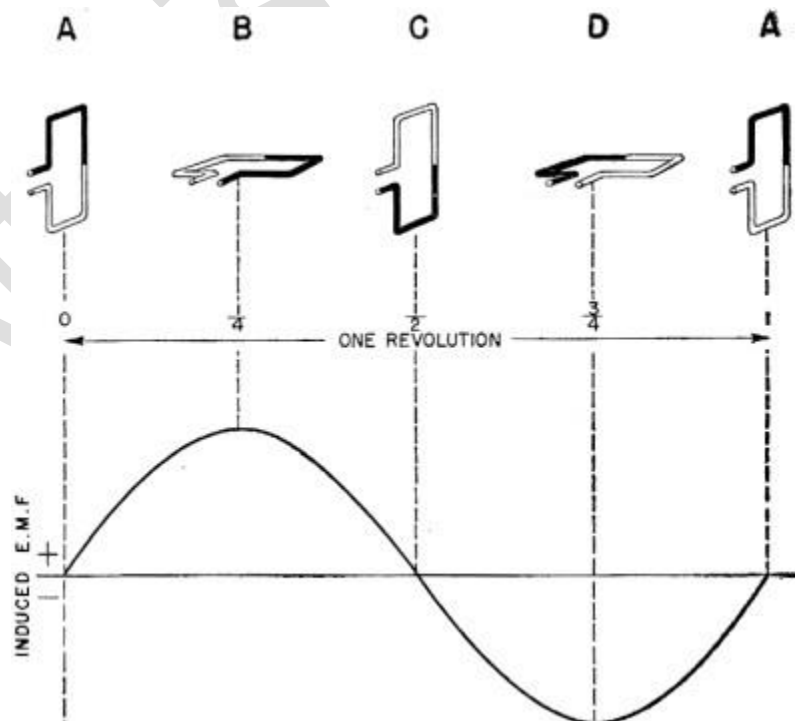
In direct current, current flows in one direction only while in alternating current, the current continuously changes direction.

It consists of a coil of wire between two permanent magnets. They generate AC current because a slip ring commutator is used.

Slip ring commutator is used to reverse the direction of current after every half rotation.

As the coil rotates magnetic flux changes and emf is induced.

The magnitude of emf is maximum when coil is horizontal as the field lines are cut fastest, and zero when coil is vertical because no field lines are cut.





Transformer

A transformer consists of two coils wrapped around a soft iron core and is used to transform voltages,

Electromagnetic induction is the working principle of a transformer.

Alternating current in the primary coil creates a changing magnetic field; this changing magnetic field links with the secondary coil and induces an alternating emf in it.

A step up transformer has more turns on the secondary coil and the voltage of the secondary coil is greater than that of the primary. A step down transformer has more turns on the primary coil and the voltage of the primary coil is greater than that of the secondary.

Transformer equation:

$$\frac{\text{no of turns of primary}}{\text{no of turns of secondary}} = \frac{\text{p.d of primary}}{\text{p.d of secondary}}$$

For a 100% efficient transformer, because power used is constant:

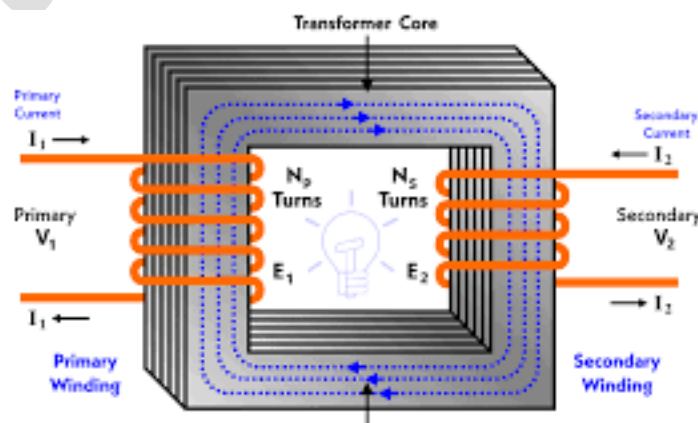
$$I_P V_P = I_S V_S$$

Transformers are used to step up voltage in power lines which reduces power loss:

High voltage, low current

Low voltage, high current

This is because a higher voltage means a smaller current and loss of power due to $P = I^2 R$ will be lower





The magnetic effect of current

The right hand grip rule determines the direction of magnetic field produced by a current carrying wire. To apply the right hand grip rule, align your thumb with the direction of the conventional current (positive to negative) and your fingers will indicate the direction of the magnetic lines of flux. This is shown in the diagram

The magnetic field produced by a current carrying solenoid is like the magnetic field produced by a bar magnet. Increasing current through wire increases the strength of magnetic field and reversing the direction of current through the wire reverses the direction of magnetic field.

The magnetic effect of current is used in relays.



Flemings left hand rule

If a current carrying conductor is placed in a magnetic field, it experiences a force due to the magnetic field.

Whenever a current carrying conductor is placed in a magnetic field, the conductor experiences a force which is perpendicular to both the magnetic field and the direction of current. According to Fleming's left hand rule, if the thumb, fore-finger and middle finger of the left hand are stretched to be perpendicular to each other as shown in the illustration at left, and if the fore finger represents the direction of magnetic field, the middle finger



represents the direction of current, then the thumb represents the direction of force. Fleming's left hand rule is applicable for motors.

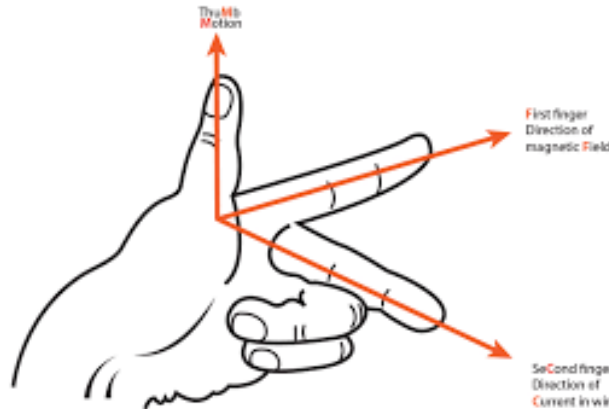
What happens if we reverse directions?

If the current is reversed, force is reversed

If the direction of magnetic field is reversed, force is reversed

If both are reversed, the force remains the same.

A force is also exerted on charged particles moving in a magnetic field (charged particles are current). If a beam of charged particles moves through a magnetic field it will be deflected showing that there is force.



DC Motor worki

A DC motor cor

Direct current flows through the wire and it experiences a turning effect due to forces exerted on it in the magnetic field. As the current flows in opposite directions on each side of the coil, the forces on each side are in opposite directions making it turn. This turning effect can be increased by:

Increasing current
Increasing number of turns on coil of wire
Use a stronger magnet

Increasing current

Increasing number of turns on coil of wire

Use a stronger magnet

A split ring commutator is used to ensure that the direction that current flows in the coil reverses after every half rotation.



Unit 5.1: The nuclear model of the atom

The atom

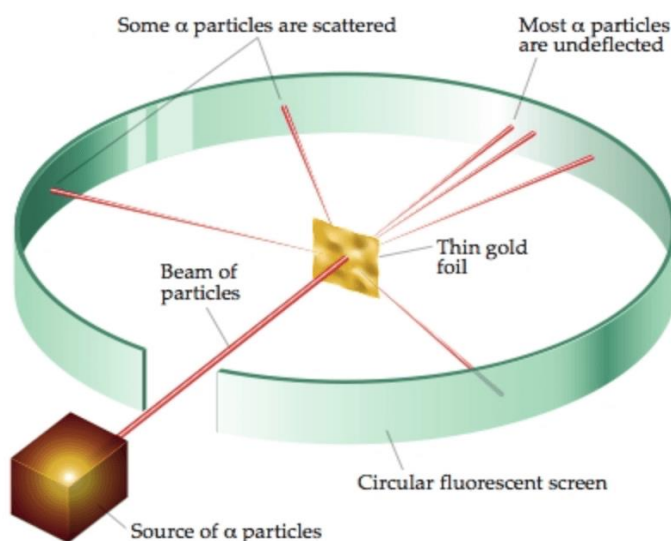
An atom is made up of a positively charged nucleus (center of the atom) and negatively charged electrons in orbit around it.

In a stable state, atoms will have a net charge of 0 as the number of protons and electrons in any stable atom is equal.

Atoms that lose or gain electrons to become charged are called ions.

Atoms have the ability to lose or gain electrons. When an atom gains or loses an electron, it can form a negative or positive ion respectively.

The Alpha-scattering experiment



The picture given above is of the alpha scattering experiment.

Background: The alpha-scattering experiment was an experiment conducted by Ernest Rutherford and his team. They fired a beam of alpha



particles at a thin sheet of gold foil, and observed how the particles were deflected.

Observations: Most alpha particles passed straight through the foil with very little or no deflection.

Some were deflected at very large angles.

An even smaller amount of particles were deflected straight backwards.

Conclusions: This led to the conclusion that the atom is mostly empty space with a very small nucleus in the center.

The nucleus is positively charged because it repelled the positively charged alpha-particles.

The nucleus contains most of the mass of the atom.

The Nucleus and subatomic particles

The nucleus is composed of protons and neutrons.



Relative Electric Charges & Masses

Subatomic Particle	Symbol	Relative Electrical Charge	Relative Mass
Proton	p^+	+1	1
Neutron	n	0	1
Electron	e^-	-1	$\frac{1}{1840}$

Aitchis



The atomic number, Z , of an element is the number of protons in the nucleus of an atom of an element.

The nucleon number, A , of an element is the total number of protons and neutrons in an element and is also known as the atomic mass.

Total number of neutrons in an atom = $A - Z$

The notation for an atom is A_ZX where A = Nucleon number, Z = Atomic Number and X = Name of element.

Nuclear Fusion and Fission

Isotopes are atoms of the same element with the same proton number but a different neutron number.

Nuclear fission is known as the splitting of nuclei whereas nuclear fusion is the joining of nuclei.

Both these processes release large amounts of energy but the energy released in fusion is much greater than that released in fission.

Example of equation of fission: ${}^{235}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{92}_{36}\text{Ba} + {}^{141}_{56}\text{Kr} + 3 {}^1_0\text{n} + \text{energy}$

Example of equation of fusion: ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + {}^1_0\text{n}$

This energy is not created, rather it is the energy released due to a slight decrease in mass of the particles which is converted to energy using Einstein's equation $E = mc^2$

The relative charge on a nucleus is equal to the number of protons in the nucleus because they each have a charge of +1

The nucleon number is the number of protons + neutrons and it is equal to the relative mass of the nucleus since it contains only protons and neutrons.



Unit 5.2: Radioactivity

Detection of radioactivity

The radiation from the environment to which we are exposed all the time is called background radiation.

Background radiation is caused mainly by (i) the gas radon, (ii) rocks and buildings, (iii) food and drink and (iv) cosmic rays.

All background radiation is not caused by natural causes. There are also artificial causes such as the nuclear industry and X-rays.

Background radiation is a type of ionizing nuclear radiation. All ionizing nuclear radiations can be measured using a detector connected to a counter.

Usually, we use a Geiger-Counter (Geiger-Muller tube connected to a counter) to measure radiation in counts/min or counts/second.

We can use background radiation measures to find a corrected count rate. So if a radioactive source is placed in front of a counter and the counter measures a rate of 350 counts/min but the background radiation is 20 counts/min, the corrected count rate for the source is $350 - 20 = 330$ counts/min.

Thus, Corrected count rate = Measured count rate - background radiation

3 Types of Nuclear emission

Radiation is emitted by the nucleus of an atom which is unstable. It might have an isotope for which the nucleus is too heavy and thus decays or because it contains too many neutrons.

Whatever the case, radiation tends to be spontaneous and completely random, meaning we cannot predict which nucleus will decay next or when it will happen, or which direction the radiation will go in.



Nuclei can emit 3 types of radiation, alpha(α), beta(β) or gamma(γ).

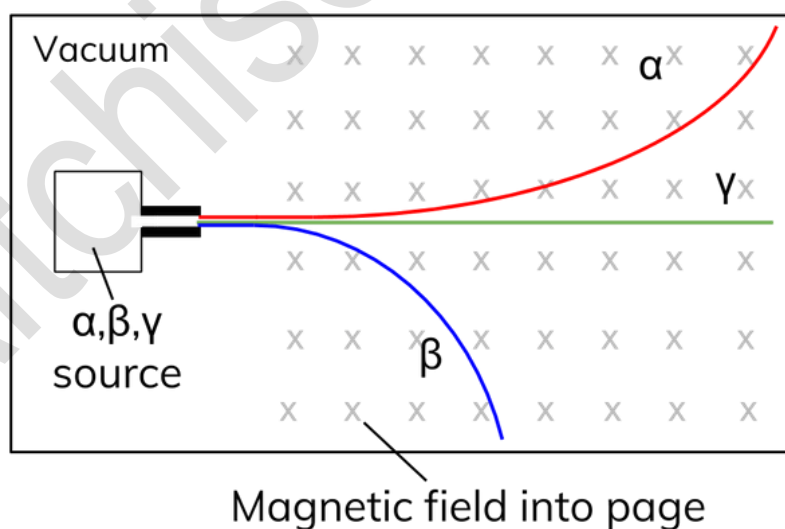
Characteristic	Alpha Particles	Beta Particles	Gamma Rays
Symbols	α , ${}^4_2\text{He}$	β , ${}^0_{-1}\text{e}$	γ
Identity	Helium nucleus	electron	Electromagnetic radiation
Charge	2+	1-	None
Mass Number	4	0	0
Penetrating Power	Minimal (will not penetrate skin)	Short (will penetrate skin and some tissues slightly)	Deep (will penetrate tissues deeply)

An alpha particle has 2 neutrons and protons and is positively charged.

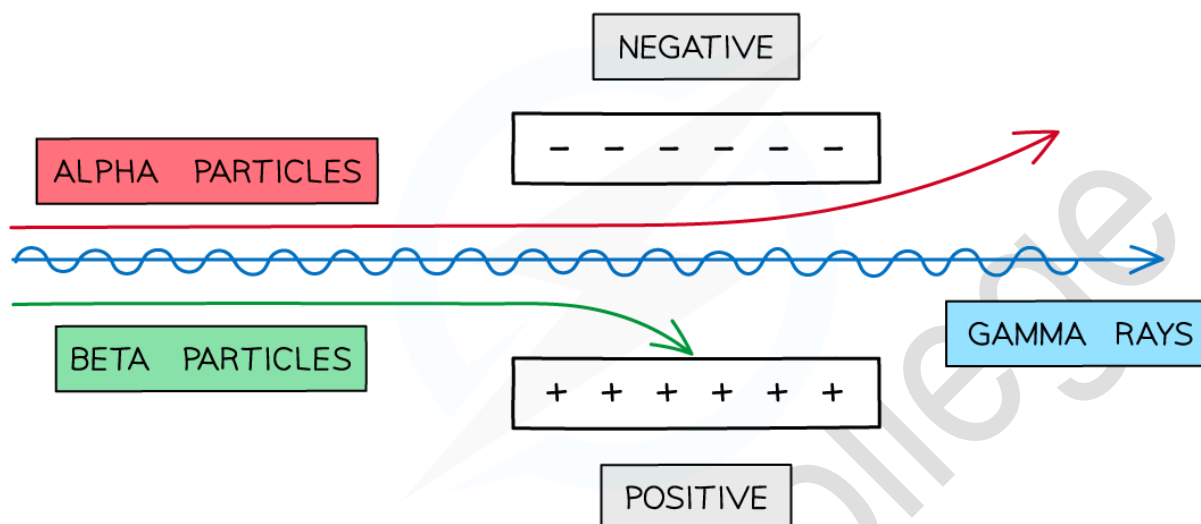
A beta particle is an electron, emitted from inside the nucleus and is negatively charged but with very little mass.

A gamma ray is a form of electromagnetic radiation with no mass or charge and it is purely energy.

Out of these, alpha radiation has the most ionizing power, then beta radiation and then gamma radiation but for penetrating power the order is opposite.



Deflection of alpha, beta and gamma particles in electric and magnetic fields



In an electric field, gamma rays pass through straight because they have no charge. Alpha particles have positive charge so they get attracted to the negative plate but due to greater mass require more force to be pulled to the plate which is why they travel for longer than beta particles, which almost immediately go to the positive plate due to low mass and a negative charge.

In a magnetic field, we can use Fleming's left hand rule to find out where the particles will go. Since gamma rays have no charge they pass straight through. Alpha particles will go upwards according to the rule and beta particles will go downwards because the direction of current is opposite that of an alpha particle since it is negative.

Ionizing effects

The ionizing effect of an alpha particle is greatest, then beta and then gamma.

This is because an alpha particle has the most mass out of the three of them and thus has the most kinetic energy so when it collides with an air molecule it is more likely to knock one of the electrons out of the air molecule. It also has the most charge because it contains two positively



charged protons so when it collides with the air molecule, the electron it will knock out will likely be charged as well.

A beta particle moves much faster than an alpha particle and has lesser kinetic energy, so is likely to travel straight through an air molecule rather than interacting with it. It also has a lesser charge than an alpha particle. Gamma radiation is uncharged and moves at the speed of light. It also has no mass. It is absorbed least in thin air due to this and is thus the least ionizing.

Radioactive decay

Radioactive decay is spontaneous and random and can emit three types of radiation, as discussed above. Out of these three types of radiation, alpha decay and beta decay cause the nucleus to change to that of a different element.

For alpha decay, a helium atom (2 protons and 2 neutrons) are given out.

For beta decay, a neutron changes to an electron and a proton and the electron is given out.

For gamma decay, pure energy is given out.

This can be exemplified below:

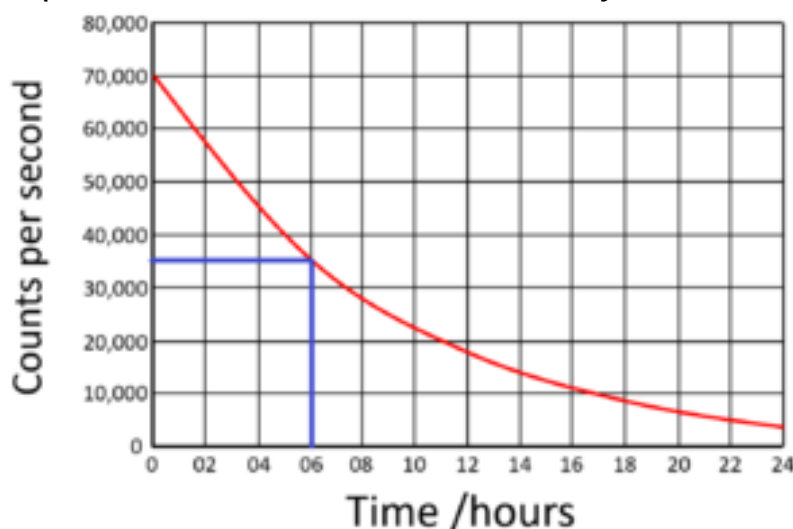
Note: The atomic numbers and nucleon numbers on both hand sides of the equation must be equal.

After decaying, the nuclei become more stable and there is a reduction in the number of excess neutrons or heaviness of the atom.



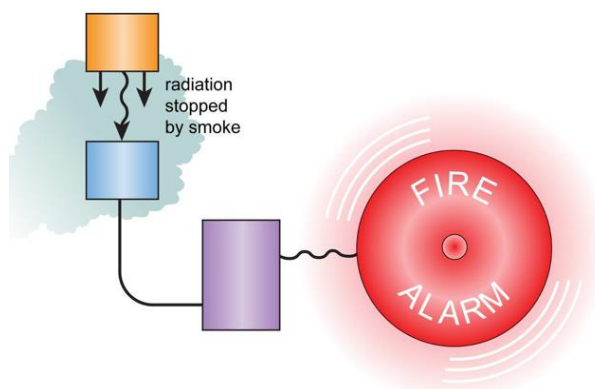
Half-lives of isotopes and their uses

The half-life of an isotope is defined as the average time taken for half the atoms in a sample of radioactive material to decay.



These isotopes are used for different purposes, which depends on their half-lives and the type of radiation emitted.

In smoke detectors, an element Americium is used, which has a long half life of about 430 years. This makes it so that the count rate of the source does not change dramatically in a long time. When smoke covers the source, however, the count rate will drop dramatically and the fire alarm will sound.





Beta radiation is used to measure thickness of papers in industry. The paper is subjected to beta radiation and a detector is placed on the other side of the paper to check if the beta radiation coming through at the other end is standard.

Gamma rays can be used in fault detection in metal pipes. If there is a fault in the pipework the radiation will escape through it.

Food decay can also be prevented by irradiation, which means killing the microbes that cause decay using intense gamma rays.

In the same way, surgical instruments can be sterilized by being sealed in plastic bags and then exposed to gamma rays to kill any microbes. Gamma radiation is used because it can penetrate through the plastic bag without it needing to be opened.

Cancer can also be diagnosed and treated through gamma rays. The gamma rays are aimed at the tumor to kill cancerous cells and destroy the tumor.

Safety Precautions for radiation

Ionizing nuclear radiation can be very harmful to us. It can cause the cell to die, cause harmful mutations and growth of tumors and lead to cancer or even affect genes of future generations if the mutation happens in a gamete cell.

Radioactive materials are thus held with care. Radioactive sources are stored and moved in lead covered storage boxes to absorb most of the radiation, and usually have a tiny opening to give out radiation in a small range.

Safety precautions for radioactivity include:

Wear Protective Suits in contaminated areas: The suit absorbs radiation and different materials can be used depending on the type of radiation you are being exposed to.

Radioactive hazard labels: This is done to warn people of the danger so that they can stay far away from the source of radiation and try not to be near it for too much time.



Photographic film dosimeter badges: These monitor the amount of radiation a person has been exposed to. After the safe limit is reached, the badges start turning from green to yellow to orange to red. Workers should be moved from the area once their safe limit is reached.

Remote Operating of Scanners: People who operate X-rays or who may work to treat cancer can often be exposed to radiation themselves. To prevent this, they can control the scanner via remote control or use a screen to prevent radiation from reaching them.

Storage boxes for sources: Explanation is given above.



Unit 6: Space Physics

The Earth's Axis

The Earth is a rocky planet that rotates in a near circular orbit around the Sun. It rotates on its axis, which is a line through the north and south poles. The axis is tilted at an angle of approximately 23.5° from the vertical. The Earth completes one full rotation (revolution) in approximately 24 hours (1 day). This rotation creates the apparent daily motion of the Sun rising and setting. Rotation of the Earth on its axis is therefore responsible for the periodic cycle of day and night. Day and Night: The Earth's rotation around its axis creates day and night. Day is experienced by the half of the Earth's surface that is facing the Sun. Night is the other half of the Earth's surface, facing away from the Sun.

Rising and Setting of the Sun

The Earth's rotation on its axis makes the Sun look like it moves from east to west. At the equinoxes, the Sun rises exactly in the east and sets exactly in the west. Equinox (meaning 'equal night') is when day and night are approximately of equal length. However, the exact locations of where the Sun rises and sets change throughout the seasons. In the northern hemisphere (above the equator): In summer, the sun rises north of east and sets north of west. In winter, the sun rises south of east and sets south of west.

The Sun is highest above the horizon at noon (12 pm). In the northern hemisphere, the daylight hours are longest up until roughly the 21st June. This day is known as the Summer Solstice and is where the Sun is at its highest point in the sky all year. The daylight hours then decrease to their lowest around 21st December. This is known as the Winter Solstice and is where the Sun is at its lowest point in the sky all year.

The Earth's Orbit

The Earth orbits the Sun once in approximately 365 days. This is 1 year. The combination of the orbiting of the Earth around the Sun and the Earth's tilt creates the seasons.



Over parts B, C and D of the orbit, the northern hemisphere is tilted towards the Sun. This means daylight hours are more than hours of darkness. This is spring and summer. The southern hemisphere is tilted away from the Sun. This means there are shorter days than night. This is autumn and winter. Over parts F, G and H of the orbit, the northern hemisphere is tilted away from the Sun. The situations in both the northern and southern hemisphere are reversed.

It is autumn and winter in the northern hemisphere, but at the same time it is spring and summer in the southern hemisphere. At C: This is the summer solstice. The northern hemisphere has the longest day, whilst the southern hemisphere has its shortest day. At G: This is the winter solstice. The northern hemisphere has its shortest day, whilst the southern hemisphere has its longest day. At A and D: Night and day are equal in both hemispheres. These are the equinoxes.

Moon & Earth

The Moon is a satellite around the Earth. It travels around the Earth in roughly a circular orbit once a month. This takes 27–28 days. The Moon revolves around its own axis in a month so always has the same side facing the Earth. We never see the hemisphere that is always facing away from Earth, although astronauts have orbited the Moon and satellite have photographed it. The Moon shines with reflected light from the Sun, it does not produce its own light. Phases of the Moon: The way the Moon's appearance changes across a month, as seen from Earth, is called its periodic cycle of phases.

In the image above, the inner circle shows that exactly half of the Moon is illuminated by the Sun at all times. The outer circle shows how the Moon looks like from the Earth at its various positions. In the New Moon phase: The Moon is between the Earth and the Sun. Therefore, the sunlight is only on the opposite face of the Moon to the Earth. This means the Moon is unlit as seen from Earth, so it is not visible. At the Full Moon phase: The Earth is between the Moon and the Sun. The side of the Moon that is facing the Earth is completely lit by the sunlight. This means the Moon is fully lit as seen from Earth. In between, a crescent can be seen where the Moon is partially illuminated from sunlight.

Orbital Speed EXTENDED When planets move around the Sun, or a moon moves around a planet, they orbit in circular motion. This means that in one orbit, a planet travels a distance equal to the circumference of a circle (the shape of the orbit). This is equal to $2\pi r$ where r is the radius of a circle. The relationship between speed, distance and time is: $\text{Speed} = \frac{\text{distance}}{\text{time}}$. The average orbital speed of an object can be defined by the equation: $v = \frac{2\pi r}{T}$ Where: v = orbital speed in metres per second (m/s) r = average



radius of the orbit in metres (m) T = orbital period in seconds (s) This orbital period (or time period) is denoted as: $2\pi r T$ The time taken for an object to complete one orbit The orbital radius r is always taken from the centre of the object being orbited to the object orbiting

The Solar System The Solar System consists of: . The Sun . Eight planets . Natural and artificial satellites . Dwarf planets . Asteroids and comets The Sun & the Planets The Sun lies at the centre of the Solar System The Sun is a star that makes up over 99% of the mass of the solar system There are eight planets and an unknown number of dwarf planets which orbit the Sun The gravitational field around planets is strong enough to have pulled in all nearby objects with the exception of natural satellites The gravitational field around a dwarf planet is not strong enough to have pulled in nearby objects The 8 planets in our Solar System in ascending order of the distance from the Sun are: Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Satellites There are two types of satellite: Natural Artificial Some planets have moons which orbit them Moons are an example of natural satellites Artificial satellites are man-made and can orbit any object in space The International Space Station (ISS) orbits the Earth and is an example of an artificial satellite

Asteroids & Comets

Asteroids and comets also orbit the sun An asteroid is a small rocky object which orbits the Sun The asteroid belt lies between Mars and Jupiter Comets are made of dust and ice and orbit the Sun in a different orbit to those of planets The ice melts when the comet approaches the Sun and forms the comet's tail

Measuring Galactic Speed & Distance EXTENDED

Using Redshift Observations to Measure the Universe The change in wavelength of the galaxy's starlight due to redshift can be used to find the velocity, v , with which a galaxy (or any distant object) is moving away from Earth Using an equation to compare the ratio of the expected wavelength with the observed wavelength, the velocity can be found; $\frac{\text{difference between actual wavelength and expected wavelength}}{\text{actual wavelength}} = \frac{\text{speed of the galaxy}}{\text{speed of light}}$ This equation will not be directly examined but the idea that the velocity of distant objects can be found from the redshift seen in easily observed wavelengths is an important one Measuring Distance Using Supernovae Redshift and CMB radiation allow various measurements of the Universe to be accurately made Measuring distance is done using different methods A key method is the use of standard candles, including supernovae Supernovae are exploding stars



Certain types have the same peak level of brightness (absolute magnitude), making them extremely useful in measuring the distance to remote stars and galaxies Type 1a supernovae are so bright that they can be seen clearly even though they may be deep inside their parent galaxy This allows the distance to the galaxy to be calculated

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