Rebekah's Physics Notes

CONTENT PAGE:

- List of Useful Physics Formulae

5105 N-Level Science (Physics)

Physical Quantity / Concept		Formula	Symbols and S.I. Units
1	density	$\rho = \frac{m}{V}$	ρ = density, kg / m^3 m = mass, kg V = volume, m^3
2	weight	$W = mg$	W = weight, N m = mass, kg g = gravitational field strength, N / kg
3	average speed	$v = \frac{d}{t}$	v = average speed, m/s d = total distance, m t = total time taken, s
4	acceleration	$a = \frac{v - u}{t}$	a = acceleration, m/s^2 v = final velocity, m/s u = initial velocity, m/s t = time, s
5	force	$F = ma$	F = force, N m = mass, kg a = acceleration, m/s^2
6	work done	$W = F \times d$	W = work done, J F = force, N d = displacement, m
7	energy in the kinetic store	$E_k = \frac{1}{2}mv^2$	E_k = energy in the kinetic store, J m = mass, kg v = speed, m/s
8	energy in the gravitational potential store	$E_p = mgh$	E_p = energy in the gravitational potential store, J m = mass, kg g = gravitational acceleration due to gravity, m/s^2 h = height of an object from a reference point, m
9	pressure	general pressure $P = \frac{F}{A}$	P = pressure, N/m^2 or Pa F = force, N A = area, m^2
10	power	$P = \frac{W}{t} = \frac{E}{t}$	P = power, W W = work done or energy transferred, J E = energy conversion, J t = time, s
11	wave equation	$v = f\lambda$ $f = \frac{1}{T}$	v = wave speed, m/s f = frequency, Hz λ = wavelength, m T = period, s
12	amount of charge	$Q = It$	Q = charge, C I = current, A t = time, s
13	Ohm's Law	$V = IR$	V = potential difference across two points, V I = current, A R = resistance, Ω

Physical Quantity / Concept		*Formula*	*Symbols and S.I. Units*
14	resistance	In series, $R = R_1 + R_2 + ... + R_n$ In parallel, $R = \left(\frac{1}{R_1} + \frac{1}{R_2} + ... \frac{1}{R_n}\right)^{-1}$ Resistance of a conductor $R = \frac{\rho l}{A}$	R = *effective resistance,* Ω $n \geq 2$ ρ = *resistivity of wire,* Ωm l = *length of wire, m* A = *cross-sectional area of wire,* m^2
15	potential difference	$V = \frac{W}{Q}$	V = potential difference, V W = work done between two points in circuit, J Q = charge, C
16	e.m.f.	$\varepsilon = \frac{\text{total work done}}{Q}$	ε = e.m.f., V Q = charge, C
17	electrical power	$P = VI = I^2R = \frac{V^2}{R}$	P = power, W V = potential difference, V I = current, A R = resistance, Ω
18	electrical energy	$E = VIt = I^2Rt = \frac{V^2}{R}t$	E = electrical energy, J V = potential difference, V I = current, A t = time, s R = resistance, Ω

CHAPTER 1:PHYSICAL QUANTITIES,UNITS AND MEASUREMENTS

Prefixes:

-Prefixes are multiples/decimals of 10 to conveniently express physical quantities that are too big or too small

	Factor	Prefix	symbol
Multiple	10^{12}	Tera	T
Multiple	10^{9}	Giga	G
Multiple	10^{6}	Mega	M
Multiple	10^{3}	Kilo	k
Sub multiple	10^{-1}	Deci	d
Sub multiple	10^{-2}	Centi	c
Sub multiple	10^{-3}	Milli	m
Sub multiple	10^{-6}	Micro	μ
Sub multiple	10^{-9}	Nano	n

Physical quantities

-physical quantities is a quantity which can be measured with a measuring instrument

Base quantities	SI unit	Unit symbol
Mass	Kilogram	Kg
Temperature	Kelvin	K
Length	Metre	M
Current	Ampere	A
Time	Second	s

Measuring physical quantities:

-length can be measured using a meter ruler and a measuring tape

Digital calipers

-is used to measure the internal and external diameters,depth of an object accurately. (0 to 15 cm)

Part	Function
Internal jaw	Measuring internal length of an object
External jaw	Measuring external length of an object
Tail	Measuring the depth of an object
Locking screw	To ensure that the jaws do not move apart
Digital display	To show numeric value

Digital Micrometer Screw Gauge

-Used to measure objects that are too small to be measure using the digital caliper (0 to 2.5cm)

Parts	Function
Anvil and spindle	Used to measure the diameter of an object
Zero button	Used to reset the displayed length back to zero
Digital display	Used to show the numeric value
Ratchet	To adjust the spindle so that it is in contact with the object

Measures to follow to ensure accurate reading:

-ensure that ratchet is turned until spindle is in contact with object

-object is placed in between anvil and spindle

-ensure that object is held tightly in between anvil and spindle

-but not too tight as this may cause damage to the object

Precision of an instrument:

-the smallest unit of an instrument can measure is known as its precision

Instrument	Measuring range
Measuring tape	0 to several meters
Meter ruler	0 to 1 m
Digital caliper	0 to 15 cm
Digital micro screw gauge	0 to 2.5 cm

Avoiding errors of measurement:

-When using a meter ruler,our eyes should be positioned such that our line of sight is perpendicular to the ruler

-if measurement errors are introduced,it is called parallax errors

Measurement of time:

Pendulum

-used to measure time

-consists of a bob attached to the end of the string fixed at the other end of the string.

-a pendulum moves back and forth at regular intervals

-the period is the time taken for the pendulum to complete one oscillation

-one oscillation is completed when a pendulum completes to and from motion
-the period of a pendulum depends on the length of the string
-human reaction time is a random error which is the source of the error that affects the accuracy of a measurement.
-to minimize the random errors,repeat the measurement several times to obtain the average of the readings
T(period of the pendulum)=$\frac{t(time\ taken\ for\ X\ oscillations)}{X\ oscillations}$

Factors that affect the period of pendulum:
The period is affected by the length of the pendulum
-the length of pendulum increases,the period increases
-the length of pendulum decreases,the period decreases
-when the period of the pendulum increase,the pendulum swings slower and vice versa
The period of a pendulum is not affected by:
-mass of bob
-amplitude of oscillation(angle of oscillation)

Scalar and Vector
-Scalar quantities are physical quantities that have only magnitude and unit
-Vector quantities are physical quantities that have magnitude,direction and unit

Scalar quantity	Speed, distance, energy, density, length, time, pressure, temperature, mass, power, work, electrical charge
Vector quantity	Velocity, acceleration, displacement, force, weight

Distance:
-distance is the total length covered by a moving object REGARDLESS of the direction
-distance is a scalar quantity.it is the total length covered in a journey without indicating the direction of motion
-distance does not specify the direction of the moving object

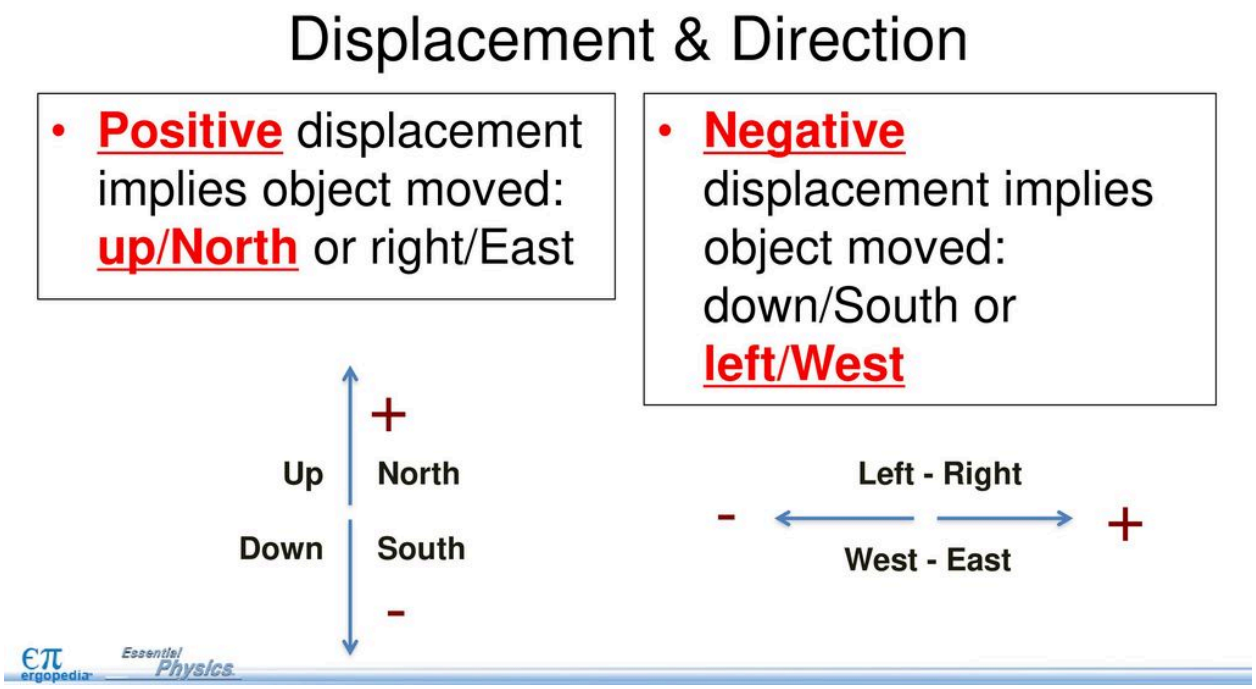
Displacement:

-displacement is the distance measured in a straight line in a specific direction

-it is the distance traveled by the object between the initial position to the final position of the object in a straight line in a stated direction

-displacement is a vector quantity as it indicates both magnitude and the direction of how the length between the point are measured

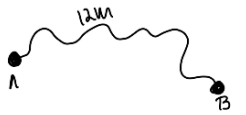
-the negative and positive signs are used to denote the direction of the motion in opposite directions.

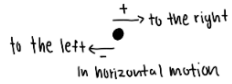


Distance vs Displacement

a distance of 2m

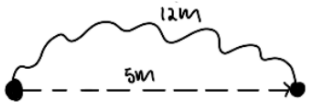
magnitude only
(scalar quantity)

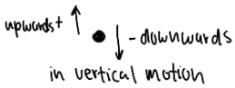




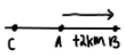
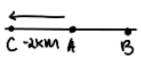
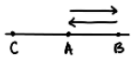
a distance of 2m due east

magnitude + direction
(vector quantity)

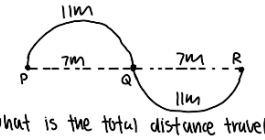




in vertical motion

Positive Displacement	Negative Displacement	zero displacement
		
A to B, Displacement is +2km	A to C, Displacement is -2km	A to A, Displacement is zero

(1) An object moving in a identical semicircle track from P to Q and then to R



a) What is the total distance travelled?

11+11 = 22m //

b) What is the displacement of the ball from P to R?

7+7 = 14m //

(2) A cyclist travels 10km due east from point A & then travel a further distance of 8km due south. The whole journey takes 2 hours.

a) Distance travelled

10+8 = 18km

b) average speed of the cyclist

average speed = $\frac{D}{T}$

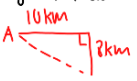
= $\frac{18}{2}$ = 9km/h

c) Displacement of cyclist from A

Displacement = $\sqrt{10^2+8^2}$

= 12.806

≈ 12.8km



D) Average velocity

Avg V = $\frac{Disp}{T}$

= $\frac{12.8}{2}$ = 6.4km/h

CHAPTER 2:KINEMATICS

-kinematics describes the motion of object without considering the force acting on it

-motion is a change in position.when an object is in motion,it changes its position

-physical quantities like distance,displacement,speed,velocity and acceleration are used to describe the motion of objects

Differences between distance and displacement

Distance	Displacement
Total length traveled a moving object,irrespective of its direction of motion	The shortest distance(straight line) between the initial and final positions of the object in a given direction
A scalar quantity(has magnitude only)	A vector quantity(has both magnitude and direction)
Always positive or zero but cannot be negative	Can be positive,negative or zero

Speed and velocity:

-speed is the change of distance per unit time OR distance traveled per unit time.

-uniform speed is when the object moves at the same speed throughout its journey,it has a uniform speed OR constant speed

-this means that the object moves at the same distance in every second or each hour

-average speed is the total distance traveled per total time taken

Average speed=$\frac{total\ distance\ traveled}{total\ time\ taken}$

-velocity is the change of displacement per unit time

-velocity is a vector quantity.it is a speed in a specific direction

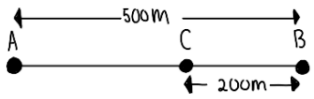
-SI unit for velocity is m/s

-the formula to determine the velocity of an object:

v=$\frac{d(displacement)}{time(s)}$

Average velocity=$\frac{total\ displacement}{total\ time\ taken}$

(1)



a person walks distance of 500m from point A to point B. he then makes a U-turn and continues to walk in the opposite direction for 200m to reach point C. the total time taken by the person for his walk from A to C is 20 minutes

(a) what is the distance traveled by this person?

500+200 = 700m

(b) what is the displacement for his journey

(+500)+(-200) = 300m

(c) determine the average speed for his walk in m/s

Average speed = $\frac{500+200}{(20\times60)}$

= $\frac{700}{1200}$

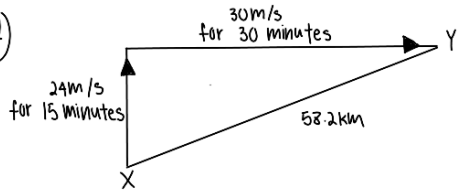
= 0.583m/s

(d) determine the average velocity for his walk in m/s

Average velocity = $\frac{displacement}{time}$

= $\frac{300}{(2\times60)}$ = 0.25m/s

(2)



the diagram shows an object traveling with a speed of 24 m/s for 15 minutes due north from point X and then with a speed of 30 m/s for half an hour due east to reach point Y. the shortest distance between points X and Y is 58.2 km

(a) find the distance when the object travels, express your answer in km

(i) at a speed of 24 m/s for 15 minutes

D = S x T

= 24 x (15 x 60)

= 21600 m

21600m ÷ 1000 = 21.6km

(ii) at a speed of 30 m/s for half an hour

30mins

D = S x T

= 30 x (30 x 60)

= 54000

54000m ÷ 1000 = 54km

(b) find the average speed of the object in km/h

S = $\frac{D}{T}$ = $\frac{21.6+54}{\frac{1}{4}+\frac{1}{2}}$ = 100.8km/h

(c) average velocity is the total displacement per total time taken. find the average velocity of the object

V = $\frac{D}{T}$

= $\frac{58.2\times1000}{3600}$ = 16.2m/s

Acceleration

Acceleration is the rate of change of velocity (change of velocity per unit time)

-it is a vector quantity as it has both magnitude and direction

-SI unit:m/s²

-when an object is said to have acceleration,it could be cause of one of the following conditions:

-a change in velocity

-a change in both velocity and direction

-when an object travels at constant velocity,it has zero acceleration

-deceleration or retardation is used to describe the velocity of an object decreases for every unit time

Formula for acceleration:

Acceleration=$\frac{V(final\ velocity)-U(initial\ velocity)}{t(s)}$

Uniform and non-uniform acceleration

-when the change in the velocity is the same for every unit of time,a moving object,is said to have a uniform(or constant) acceleration

-when the change of velocity is not the same for every unit of time,a moving object is said to have non-uniform acceleration

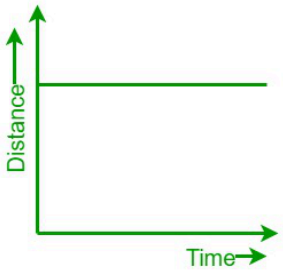
-acceleration due to free-fall is ALWAYS 10m/s²

-distance=area under speed-time graph

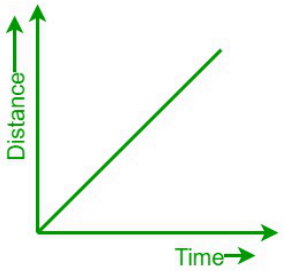
A gymnast jumps onto a trampoline and bounces upwards. On a second occasion, the gymnast bounces higher What remains constant on both occasions?	The gymnasts acceleration in the air remains constant -since the height reached is different,the GPE will be different -the acceleration of free-fall is due to the earth's gravity, and is constant at 10m/s² near the surface of the earth

Graph interpretation:

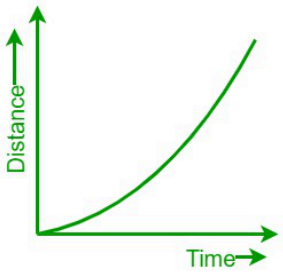
distance time graph-represents speed



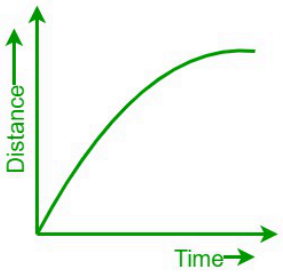
For Stationary body



(For uniform motion)



(For non-uniform motion when speed increases)



(For non-uniform motion when speed decreases)

Speed time graph-represents acceleration

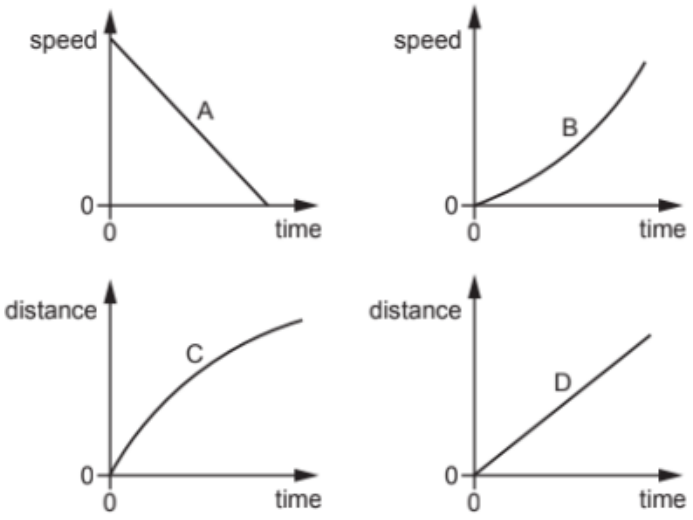


Fig. 1.1

CHAPTER 3:FORCE AND PRESSURE

-there are two main groups of forces,*contact and non-contact*

Type of force	What is it?	Example
Contact	-a force that results when two interacting objects are in direct contact with each other	Frictional force: -opposes or tends to oppose motion between surfaces in contact Air resistance: -a type of frictional force exerted by air to oppose the motion of moving objects Normal force: -a push exerted by a surface on an object pressuring it Tension: -a pull exerted by a stretched spring,string or rope on an object attached to it.
Non-contact	A force applied to an object by another object that is not in direct contact with it	Gravitational force: -a pull acting on an object due to earth's gravity Magnetic force: -attractive or repulsive force between magnets Electrostatic force: -attractive or repulsive force between electric charges

Mass:

-mass is a measure of the amount of matter in an object
-it is a scalar quantity
-the SI unit for mass is kilogram(kg)
-the beam balance and the electronic balance are used to measure the mass of an object
-the mass of an object is constant and is not affected by the gravitational field strength(g) of a planet
-its a basic property of a body and cannot be changed by the location,shape and speed of the body

Gravitational Field:

-all objects with mass attracts each other.the attractive force between objects with mass is known as the gravitational force or force due to gravity or weight
-a gravitational field is a region in which a mass experiences a force due to gravitational attraction
-however the gravitational force of attraction of an object is only significant if the object has a huge amount of mass,such as earth
(the greater the mass,the greater the pull)
-we can feel the gravitational force of the earth in its gravitational field because it has a very huge mass,so its gravitational force is strong enough to pull us toward its center.

Gravitational Field Strength:

-the gravitational field strength at a point describes how strong or weak a gravitational field is at that point
-the gravitational field strength at a point,g,is defined as the gravitational force per unit mass placed at that point
-the unit for gravitational field strength is N/kg
-the gravitational field strength if earth near the surface is the strongest and gets weaker if further away from its surface
-the gravitational field strength near the earth's surface is approximately 10N/Kg
-meaning that every 1kg object near the surface if the earth will experience the gravitational force of 10N acting on it

Weight:

-the amount of gravitational force exerted on an object with a particular mass is known as the weight or force due to gravity.

-weight is defined as the gravitational force acting on an object that has mass

Hence,the gravitational field strength,weight and mass of can object can be related in the following formula:

$w = mg$

w=weight or force due to gravity (N)

m=mass of object (K)

g=gravitational field strength(N^2)

-from the formula,it shows that the weight of an object depends on the gravitational field strength it is in and the mass of the object

-the greater the gravitational field strength,the greater the weight of the object

-the greater the mass of the object,the greater the weight of the object

-the gravitational field strength varies in different planets or locations,so the weight of an object will change

EG:

	Earth's surface	Moon's surface
Gravitational field strength	10N/kg	1.6N/kg
Weight of 1kg mass	10N	1.6N

-this means that it would be easier to lift a mass on the surface of the moon than on the earth because it has a smaller weight(or smaller force due to gravity)

-the weight of an object can be measured using a spring balance

Gravitational Field Strength and Acceleration due to Free Fall

-gravitational field strength of earth=10N/kg

-acceleration due to free fall=10N/kg

-both acceleration and resultant force acting on an object can be related to the following formula:

$F = ma$
F=resultant force (N)
m=mass of object (kg)
a=acceleration(m/s²)

Mass	Weight
Measurement of quantity of matter in a body	Measurement of gravitational force acted on a body
Constant everywhere	Varies with g
SI unit is kilogram(kg)	SI unit is newton(N)

Density
-density is a measure of mass per unit volume
-the SI unit for density is kilogram per cubic metre (kg/m³)
-the density indicates how a matter is being packed in a given volume
-the higher the density,the greater the mass
-every substance has a fixed density value hence,it is possible to identify an unknown pure substance by determining its density
-an object floats on a liquid if its density is lower than the liquid
-an object sinks in a liquid if its density is higher than the liquid
Formula to determine the density of an object:
$p = \frac{m}{v}$
p=density(kg/m³)
m=mass(kg)
volume=(m³)

Pressure
-pressure is a force acting perpendicularly on unit area of a surface
$P = \frac{F}{A}$
P=pressure(Pa or N/m²)
F=force(N)
A=area(m²)

Factors affect the magnitude of pressure:

-force acting perpendicularly on a surface

-area of contact

When the surface area is small,the pressure exerted by the object is more

-SI unit of pressure is pascal (Pa) or N/m²

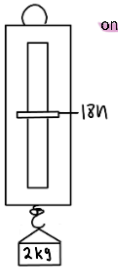
-pressure is an important concept in our everyday application

Application	Change of pressure
Knife	Smaller area to increase pressure
Boots	Smaller area to exert greater pressure on floor as to present slipping
Skis	Larger surface area to reduce pressure so that it is easy to move on the ground

the table shows the weight in Newton's of a 10kg mass on each of the four planets

PLANET	Weight of a 10kg mass/N
Earth	100
Jupiter	250
Mercury	40
Venus	90

the diagram shows a force metre (spring balance) being used on one of these planets



on which planet is the force (spring balance) being used?

$W = mg$ $g = \frac{W}{m}$

Earth: $\frac{100}{10} = 10N/kg$

Jupiter: $\frac{250}{10} = 25N/kg$

Mercury: $\frac{40}{10} = 4N/kg$

Venus: $\frac{90}{10} = 9N/kg$

spring balance: $g = \frac{W}{m} = \frac{18}{2} = 9N/kg$

∴ Venus

(a) the density of a substance is 1.3kg/m³. convert the density to g/cm³

kg → g = × 1000

= 1.3 × 1000

= 1300g

$m^3 \rightarrow cm^3$: $1m = 100cm$

$1m^3 = 1 \div (10^{-2})^3 cm^3$

$= \frac{1}{10^{-6}}$

$= 10^6 cm^3$

$1.3kg/m^3 = 1.3kg/1m^3$

$= 1300g / 10^6$

$= 1.3 \times 10^{-3} g/cm^3$

(b) an object has a density of 0.25g/cm³. what is its density in kg/m³?

g → kg = ÷1000

= 0.25 ÷ 1000

$= 0.25 \times 10^{-3}$

$cm^3 \rightarrow m^3$: $1cm = 10^{-2}$

$1cm^3 = 1 \times (10^{-2})^3 m^3$

$= 10^{-6}$

$\frac{0.25g}{1} = \frac{(0.25 \times 10^{-3})kg}{(10^{-6})m^3}$

$= 250kg/m^3$

a tank of length 3m has a width of 1m and a height of 0.5m.
it is filled with a liquid which weighs 12000N.
calculate the pressure on the base of three tank exerted by the liquid

$P = \frac{F}{A} = \frac{12000}{3} = 4000 Pa$

CHAPTER 4:DYNAMICS

Effects of a force on the motion of a body

-a force is a push or pull acting on an object

Eg:

-typing on a keyboard(push)

-opening a drawer(pull)

-the SI unit for force is newton (N)

-a force is measured by a spring balance or dynamometer

Effects of a force on an object:

-causes stationary object to start moving

-causes moving object to stop moving

-causes moving object to speed up or slow down

-changes the direction of the moving object

Friction

-friction is a force exerted by a solid surface or a fluid medium on an object when the object moves through it.

-friction is a contact force that opposes or tends to oppose motion between surfaces in contact.

-friction is parallel to the contact surfaces and opposite to the direction of the applied force.

-friction opposes motion between surfaces in contact due to the irregularities of the surfaces

-when two surfaces slide over each other,the surface irregularities catch onto each other to resist motion

-rough surfaces have larger irregularities than smooth surfaces.hence,rough surfaces provide more friction than smooth surfaces

negative effects of friction can be reduced by one of the following ways:

-using ball bearings

-using wheels

-using air cushion

-using lubricants and polished surfaces

Examples of enhancing the positive effects of friction when friction is useful:
-applying chalk powder to absorb moisture to improve grip on other objects
-using parachute to increase the surface area in order to increase air resistance so that objects fall slower towards ground
-shoes designed with threads to increase friction and prevents slipping

Falling objects with air resistance:
-when an object falls in the air,two forces in opposite directions are acting on it:
-a downward acting force of weight(W=mg)
-an upward acting force of air resistance (a type of friction that always opposes the direction of motion)
Resultant force acting on the falling object in the air
=weight +(- air resistance)
=weight - air resistance
Factors affecting the magnitude of air resistance:
-surface area
-as the surface area increases,air resistance decreases

A force is a vector quantity hence,it has a magnitude and direction
¨+¨ and ¨-¨ is used to indicate forces acting in opposite directions

Balanced forces	Unbalanced forces
-forces that will not change the motion of a body -resultant force and balanced force=0N Forces that causes 1)object to remain stationary if it was stationary before 2)object to continue moving at constant velocity if it was moving	-forces that causes 1)a stationary body to move 2)a moving object to change its velocity -a resultant force of unbalanced force ≠ 0N

When forces acting in opposite directions have the same magnitude,they are said to be balanced because the resultant force is zero.

Resultant force=sum of all forces

Eg: 10N +(-10N)

=0N

When forces acting in opposite directions have different magnitudes,they said to be unbalanced because the resultant force is not zero

Resultant force=sum of all forces

Eg: 10N+(-8N)

=10N-8N

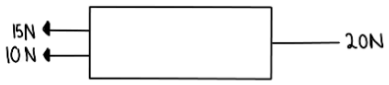
=2N

When the resultant force acting on an object is not zero:

-the velocity of the object can change

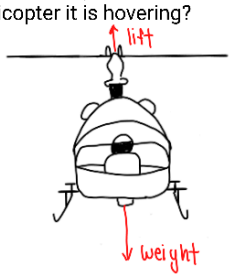
-the direction of the object can change

a body has three forces acting on it
what is the resultant forces on the body?



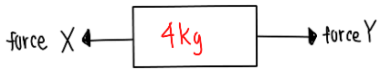
Total force to the left = (15+10)N
= 25N
Total force to the right = 20N
Resultant force = (25-20)N
= 5N to the left //

the diagram shows a helicopter hiding stationary in the air
(a)what can you conclude about the size of the forces acting on the helicopter it is hovering?



When the helicopter is hovering, the size of each of the forces is the same

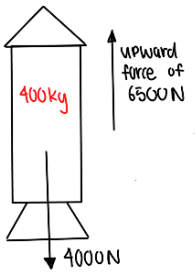
an object of mass 4kg has two forces acting on it as shown
the object is accelerating at 2m/s² to the right
what are the forces of X and Y?



f=ma
= 4x2
= 8N

2m/s² to the right
= X<Y
Y-X = 8N
Y=12 , X=4 //

the diagram shows a small rocket of mass 400kg at the point of take- off
if the upward force of 6500N is produced from the engine and the weight of the rocket is 4000N
calculate the acceleration of the rocket when it launches from the point of take-off



Resultant force = 6500-4000
= 2500

f=ma
a= f/m
= 2500/400
= 6.25m/s²

Balanced force and newton's first law

-newton's first law of motion is also called the law of inertia

-newton's first law of motion states that every object will continue in its state of rest or uniform motion in a straight line unless a resultant force acts on it

-when the resultant force acting on an object is zero,the object will behave in any one of the two observations according to newton's first law of motion

Unbalanced forces and newton's second law

-forces have both magnitude and direction

-two or more forces acting on an object can be combined into a single force called the resultant force

When a resultant force acts on an object of a constant mass,the object will accelerate in the same direction of the resultant force

-newton's second law of motion states that when a resultant force acts on an object of a constant mass,the object will accelerate in the direction of the resultant force

Hence,newton's second law explains the following important observations:

-a resultant force will cause an object to change its velocity

-the greater the resultant force,the larger the acceleration

-the greater the mass of an object,the smaller the acceleration experienced

Formula for resultant force:

$F = m\,x\,a$

F=resultant force(N)

m=mass(kg)

a=acceleration(m/s^2)

Newton's third law:

-newton's third law of motion states that forces are always produced in pairs with opposite directions and equal magnitude

OR

-newton's third law of motions states that to every action there is an equal and opposite reaction

Characteristics of newton's third law of motion:

-forces occurs in pairs-an action and a reaction forces

-action and reaction forces are equal in magnitude

-action and reaction forces act in opposite direction

-action and reaction forces act between two different objects

Free-body Diagram

-free-body diagrams are used to visualize all the forces acting on an individual object ot a system to find the resultant force acting on it in a particular direction

-arrows are used to indicate all forces acting on a single object(do not draw action-reaction pairs)

CHAPTER 6:ENERGY

Energy stores:

-energy is the ability to do work

-'Work' refers to the energy that has been transferred

-SI unit for energy is joule(J)

- an energy system refers to an object or a group of objects that are energy stores

-energy stores are ways in which energy can be stored.hence,different types of energy stores energy in a particular way

Energy store	Description	Examples
Kinetic store	Energy stores in a moving object	-moving car -falling ball
Elastic potential store	Energy stored when an object is stretched, compressed or twisted	-compressed spring -stretched rubber band
Internal(thermal) store	Energy stored in a hot object	-hot coffee -heated cooking pan
Gravitational potential store	Energy stored in an object raised above ground(raised up against the gravitational pull)	-kites -a ball on a table
Nuclear store	Energy stored within the nuclei of atoms	-nuclear fission -nuclear fusion -radioactivity decay
Chemical potential store	Energy stored within chemical bonds between atoms	-food -fuels -batteries

-within an energy system,energy can be stored and transferred in different ways

Energy Transfer

-when an energy system changes,energy is transferred.when this energy gets transferred,it will go from one energy store into another.

-there are four main pathways that enable energy to transfer from one energy store to another

1.<u>energy transferred mechanically by a force acting over a distance</u>

–rotating,pushed,squashed,pulled,raised etc.

EG:

When a ball is thrown in the air,energy is transferred from the kinetic store of the person to the kinetic store of the ball mechanically.as the height of the ball increase,the gravitational pull causes the object to slow down.as the ball slows down,energy is transferred from the kinetic store of the ball to the gravitational potential store of the ball mechanically.

2.<u>energy transferred by heating due to a temperature difference between two objects</u>

-energy is transferred from a hotter region to a cooler region.

-can occur in three different ways –conduction,convection and radiation

EG:

When a kettle is turned on,energy is transferred from the internal(thermal) store of the heating element to the internal store of the water by heating due to a temperature difference between the heating element and the water.as the amount of energy in the internal store of the water increases,the water becomes hot.

<u>3a.energy transferred by propagation of EM waves</u>

-EM waves –gamma rays,X-rays,ultraviolet,visible light,infrared,microwaves and radiowaves

EG:

-when a lamp is turned on,energy is transferred from the internal store of the lamp to the internal store of the surroundings by EM waves.as a result,the air in the surroundings becomes hotter as the energy in its internal store increases

3b.energy transferred by propagation of sound waves
-transfer of sound energy from the source to the person →increase in kinetic store of persons ear drum
EG:
-When a car hits an obstacle,energy is transferred from the kinetic store of the car to the kinetic store of the car of our eardrum by mechanical sound waves.as the energy in the kinetic store of our eardrum increases,the vigorous vibrations of eardrum enables us to hear a loud bang.

4.energy transferred electrically by an electric current
-an electrical current flowing in a circuit(or energy transferred by a charge moving through a circuit)
EG:
When the switch of a shaver is closed,an electric current flows in the circuit.energy will be transferred from the chemical potential store of the battery to the kinetic store of the motor electrically therefore,the energy in the kinetic store of the motor enables it to rotate

Energy can be transferred between different energy stores of a single object or between the energy stores of different objects in an energy system
EG:

A falling stone	Energy is transferred from the gravitational potential store of the stone to the kinetic store mechanically
A trampoline pushing a girl into the air	Energy is transferred from the elastic potential store of the trampoline to the kinetic store of the girl mechanically
A battery powering a torch	Energy is transferred from the chemical store of the battery to the internal store of the bulb via electrically by the flow of electric current

-When energy is transferred from one energy store to another,work is done(meaning that transfer of energy is done)

Energy in the kinetic store of an object

-formula for calculating the amount of energy in the kinetic store:

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

E_k=energy in the kinetic store(J)

m=mass(kg)

v=speed (m/s)

Energy in the gravitational potential store

-formula for calculating the amount if energy in the gravitational potential store:

$E_p = mgh$

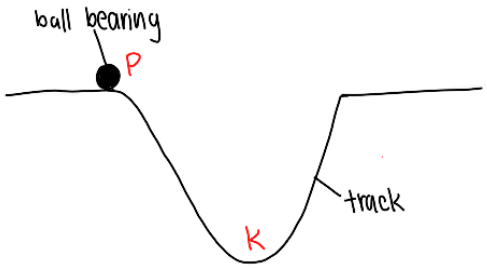
E_p=energy in the gravitational potential store

m=mass

g=gravitational field strength(N/kg)

h=height(m)

a small bearing is released from the top of the sloping part of a track
the ball bearing moves along the track
(a) with the letter P, mark a point on the track where the ball has the greatest gravitational potential energy
(b) with the letter K, mark a point on the track where the ball has the greatest kinetic energy



the ball has the greatest gravitational potential energy at the highest point on the track .
the ball has the greatest kinetic energy at the lowest point on the track, as the gravitational potential energy is converted to kinetic energy

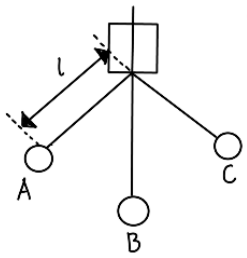
a man uses a pulley system to lift a sack of rice. the sack of rice has a mass of 25kg and it takes 5s to lift the sack 6m above the ground
use g=10N/kg
(a) calculate the gravitational potential energy gained by the sack of rice when it is lifted 6m above the ground

$E_p = mgh$
$= 25 \times 10 \times 6$
$= 1500\,J$

(b) calculate the power supplied by three man to lift the sack of rice 6m above the ground

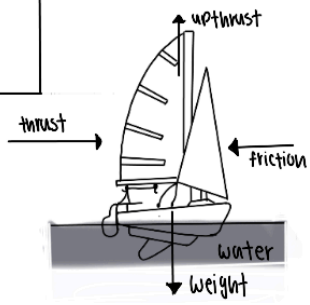
$\text{power} = \frac{\text{work done}}{\text{time}}$
$= \frac{1500}{5}$
$= 300\,W$

a student swings a pendulum as shown in the diagram
in which position A,B or C, does the metal Bob have maximum kinetic energy?



B (lowest point)

a racing yacht is moving at a constant speed on smooth water
the diagram shows the direction of the four forces acting on the yacht
the total mass of the yacht is 5000kg
calculate the kinetic energy of the yacht when it is moving at a speed of 4.0m/s



$E_k = \frac{1}{2}mv^2$
$= \frac{1}{2} \times 5000 \times 4^2$
$= 40000\,J$

Principle of Conservation of Energy

-no matter how energy is transferred from one store to another in an energy system,there is no net change in total energy.therefore,energy is always conserved

the principle of conservation of energy states that:

-energy cannot be created or destroyed energy can be transferred from one energy store to another the total energy of an isolated system is constant

Work Done

-work done by a constant force on an object is the product of the force and the distance moved by the object in the direction of the force

-work is done only when a force causes an object to move over a distance.if a force acts on an object but the object does not move over a distance,there is no work done.

Formula for calculating work done:

$W = Fd$

w=work done(J)

F=constant force(N)

d=distance moved in the direction of the force(m)

-the SI unit for work done is joule (J)

-work done is equal energy transferred,so they have the same unit

-hence,1N=1J

-since work done involved a force acting on an object to move it over a distance,energy is transferred mechanically to the kinetic store of the object

-if friction is present,some energy will also be transferred mechanically to the internal store of the object and the surroundings

Power

-power is the work done or energy transferred per unit time

-power tells us how quickly energy is used ot transferred

Formula for calculating power:

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

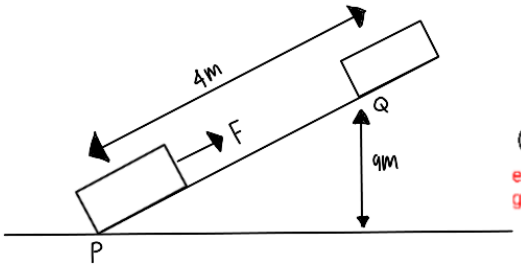
P=power(W)

W=work done(J)

E=energy transferred(J)

t=time taken(s)

a box of mass 0.5kg is pushed along a slope from P to Q buy a force F of 12N as shown in the diagram below. take g=10N/kg



(a) calculate the work done by force F to move the box from P to Q

Work done = force x distance
= 12N x 4m
= 48J

(b) calculate the amount of energy in the gravitational potential store of the box at the top of the slope

E_p = mass x GFS x height
= mgh
= 0.5kg x 10N x 9m
= 45J

(c) the work done by force F is not equal to the amount of energy in the gravitational potential store of the object at the top of the slope. explain the discrepancy

there is friction when moving the box up the slope. some of the work done is transferred mechanically to the internal store of the object and the surroundings by friction. therefore, the total work done by force F will not be transferred completely to the gravitational potential store of the box

(d) what is the work done against friction from P to Q?

Total WD = WD against friction + E_p of the box
48J = WD against friction + 45J
WD against friction = 48J - 45J
= 3J

(e) describe the main energy transfer process when the box is moved from P to Q

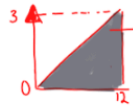
energy is transferred mechanically when the work is done by the force F in pushing the box to the gravitational potential store of the box and to the internal of the box and the surroundings

a car has a mass of 2000kg. it accelerates from rest to 3m/s in 12s. the frictional force on the road is 300 N

(a) calculate the force exerted by the car engine

Given: m = 20
$a = \frac{v-u}{t} = \frac{3-0}{12} = 0.25 m/s^2$
F = ma
= 2000kg x 0.25 = 500N

(b) what is the total work done by the engine during the acceleration of the car?



Distance = Area under graph
$= \frac{1}{2} \times 3 \times 12$
= 18m
W = F x D
= 800 x 18 = 14400J

(c) calculate the power of the car engine $P = \frac{W}{t} = \frac{14400J}{12s} = 1200W$

CHAPTER 7:KINETIC PARTICLE MODEL OF MATTER

States of matter:

-matter is made up of particles

-in room temperature,matter exists as a solid,a liquid or a gas

-the particles in a mater arrange and behave differently in different physical states

Kinetic model of particles in matter

-the physical properties of a matter are related to the molecular structure of particles in it,

-the kinetic particle model of matter is made up of tiny particles that are in continuous motion

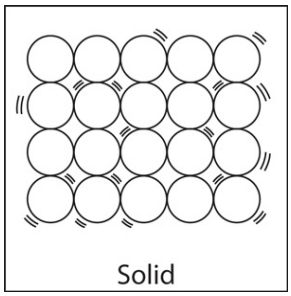
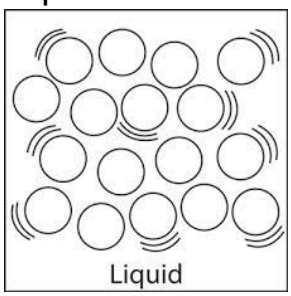
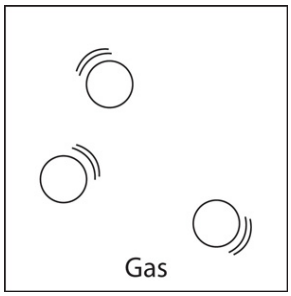
-there are attractive forces between particles of opposite charges in matter

-the particles have kinetic store due to their vibrating motion and the potential energy store due to attractive forces between them

-the sum of the kinetic and potential energy stores is the internal store of matter

-internal store=sum of kinetic store and potential energy store

Physical state	solid	Liquid	gas
Shape	Definite	Takes the shape of containers	Indefinite
volume	Definite	definite	Indefinite
Compressibility	Low	Low	high

Diagram of particles	Solids: 	Liquids: 	Gasses: 
Arrangement of particles	Particles are very closely packed together in an orderly manner	Particles are closely packed together in a disorderly manner	Particles are far apart and have a random arrangement
Movement of particles	Particles can only vibrate and rotate about their fixed positions	Particles can vibrate,rotate and move around one another randomly/slide past one another	Particles moves around freely and randomly at high speed in all direction
Forces of attraction between particles	Particles are held together by very strong attractive force	Particles are held together by strong attractive force but weaker in solids	Particles are held together by very weak attractive force

Temperature and average kinetic energy:

-in kinetic theory,all matter consists of particles(atoms or molecules) in motion

-according to the kinetic theory,the temperature of a matter is a measure of the average kinetic energy of its particles inside it.

Changes in physical states:

Matter changes states when they gain or lose energy

-melting is the change from the solid state to the liquid state when energy is transferred to the substance

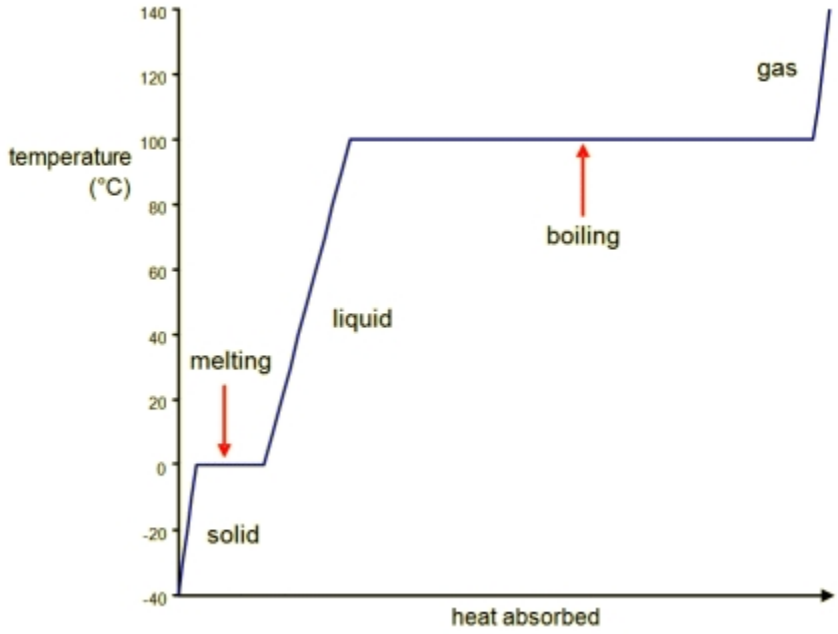
-freezing is the change from the liquid state to the solid state when energy is transferred out of the substance

-boiling is the change from the liquid state to the gaseous state when energy is transferred to the substance

-condensation is the change from the gaseous state to the liquid state when energy is transferred out of the substance

-During these 4 processes,energy transfer is related to the potential energy component of the particles only.since there is no change in the average kinetic energy of the particles,the temperature remains the same.

From solid to liquid to gas



-Temperature remains constant as heat if being supplied to weaken the intermolecular bonds between the molecules to allow them to move further apart

In solid,liquid and gas,

-When a substance is heated,energy absorbed allows the particles to vibrate or move faster,so their average kinetic energy increases. Hence,the temperature increases.

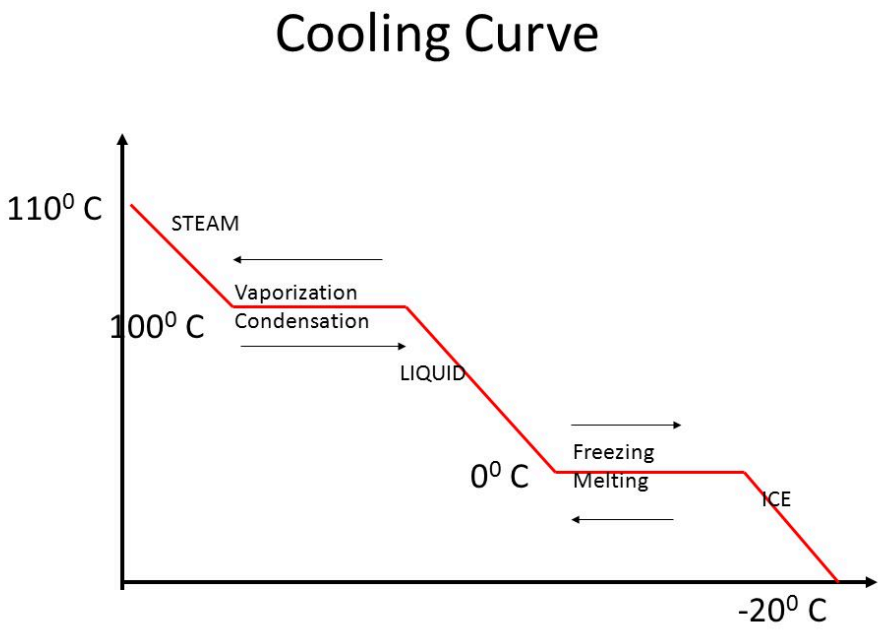
-the potential energy of the particles also increases as the average separation of the particles increases

During melting and boiling,

-energy transferred to the substance allows work done against the intermolecular forces between particles,so the average separation of the particles increases and hence,the potential energy increases

-the kinetic energy of particles remains the same,,so the temperature remains constant

From gas to liquid to solid



-Temperature is constant as heat is being released to strengthen the intermolecular bonds between the molecules to allow them to move closer

In gaseous,liquid and solid states

-when a substance is cooled,energy is transferred out of the substance.the average kinetic energy of the particles decreases,so the temperature decreases

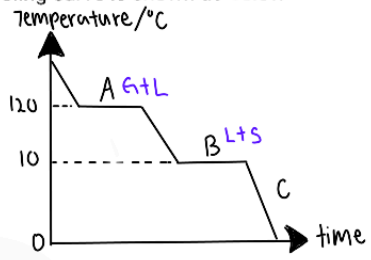
-the potential energy of the particle also decreases as the average separation of the particles decreases

<u>During condensation and solidification:</u>

-energy is transferred out of the substance,the average separation of the particles decreases,so the potential energy decreases

0the temperature remains constant as the kinetic energy of the particles remains constant

a cooling curve is shown as below



(a) name the process in

(i) A condensation

(ii) B freezing

(b) freezing point of the substance

10°C

(c) from the graph, predict the temperature at which the substance

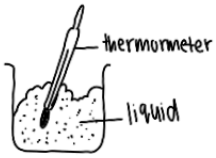
(i) changes from liquid to gas 120°C

(ii) undergoes melting 10°C

(d) state the physical state of the substance in C

solid

a student carried out an experiment as shown below to determine the boiling point of a liquid by heating the liquid with a Bunsen burner



when the liquid is heated until it bubbles vigorously, the thermometer shows a constant temperature of 65°C

(a) name the process that is taking place

boiling

(b) explain why the temperature remains constant when the liquid starts to bubbles vigorously

the temperature remains constant because the liquid molecules are gaining energy to overcome the strong forces of between the liquid molecules .thus, the temperature does not interfere

(c) describe how energy is transferred from the heat source to the liquid

energy is transferred from the chemical potential store of the Bunsen burner to the internal store of the liquid

(d) what can you say about the average kinetic energy of the particles in the liquid during this process?

remains the same

use the kinetic particle model of matter to explain:

(a) solids and liquids have a fixed volume.

explain in terms of the attractive forces and motion of their particles

particles in solids and liquids are held by strong and moderate attractive forces respectively, so the solid particles can vibrate at their fixed positions only and liquids can only move about freely in confined areas

what is internal energy?

the energy possessed by the particles in a substance which consists of kinetic energy and potential energy

CHAPTER 8:THERMAL PROCESSES

Energy transfer by heating

-energy is transferred from a region of higher temperature to a region of lower temperature by heating until both regions have the same temperature

-when both objects have the same temperature,they are said to be in a state of thermal equilibrium

-thermal equilibrium is the state in which two or more objects have the same temperature and that there is no net transfer of energy between them.

How energy is transferred when there is temperature difference between two objects/regions

For hot object;	For cold object;
-temperature of the hot object is higher than the surroundings. -energy will transfer from the internal store of the object to the internal store of the surroundings by heating -as the energy in the internal store of the object decreases,its temperature decreases.at the same time,as the energy in the internal store of the surroundings increases,its temperature increases -when both the object and the surroundings reach the same temperature,there is no net transfer of energy between them	-temperature of the cold object is lower than the surroundings -energy will be transferred from the internal store of the surroundings to the internal store of the object by heating -as the energy in the internal store of the object increases,its temperature increases.at the same time,as the energy in the internal store of the surroundings decreases,its temperature decreases -when both the object and the surroundings reach the same temperature,there is no net transfer of energy between them.

-there are three mechanisms for energy transfer by heating
1.conduction
2.convection
3.radiation

Conduction(solids):

-conduction is the process of energy transfer where energy is transferred through the passing of vibrational motion from one particle to another
-the ability of a material to transfer energy by heating through conduction depends on how quickly energy is transferred from the hotter end to the cooler end
-a good thermal conductor is a material that transfers energy quickly through conduction
-a thermal insulator is a material that transfers energy slowly through conduction
-energy transferred by heating through conduction can take place in two ways:
-through the vibrations of particles(in metals and non-metals)
-through the motion of free electrons(in metals mainly)

Vibrations of particles:

-particles in solids vibrate at their fixed positions
-they have strong attractive force between them,so they cannot move about freely
-when energy is first transferred to particles at one end of a solid,the particles will vibrate more vigorously about their fixed positions and the temperature of this region starts to increase.as a result,this end of the solid becomes hotter
-these more energetic particles at the hotter end will then transfer energy to the less energetic particles at the colder end through collisions
-the colder end of the material furthest away from the heat source will eventually become hot when the particles in it become more energetic also.hence,its temperature increases also.
-in conduction,the more energetic particles can collide and transfer energy to the less energetic particles easily when they are close together
-this explains why conduction is not effective in liquids and gasses because their particles are further apart than in solids.therefore,the chances for

particles to transfer their energy by collisions in liquids and gasses are lower

Motion of free electrons(in metals only):

-metals have free electrons that move freely throughout metals

-when these free electrons gain energy from the energetic particles at the heated end,they move quickly and easily to the cooler end

-as the free electrons move towards the cooler end,they collide and transfer energy to the particles at the cooler end.Therefore,the particles at the cooler end can vibrate more vigorously and quickly with the help of free electrons.

-thus,metals are the best thermal conductors compared to other non-metallic materials such as wool,wood,glass and plastics.

Convection(fluids)

-convection is a process of energy transfer by means of convection currents of a fluid(liquid or gas) due to a difference in density

-convection is the process by which heat is transmitted from one place to another by the movement of heated particles of a gas or liquids.

-we learnt that heat is transferred from a hotter region to a colder region similarly,we can apply this to convection currents.

Mechanism of convection currents:

-convection currents are created when there is a change in density in different parts of the fluid

-when a fluid is heated,the particles at the bottom vibrate stronger and occupy more space.the volume increases,so the density decreases.

-the less dense fluid rises up,bringing together the heat energy and takes the space of the more dense fluid that is sinking

-when the fluid loses energy to the surrounding at the top,the particles vibrate less vigorously and occupy space.the volume decreases so its density increases.

-the denser fluid sinks to the bottom,creating a convection current

-the convection current continues until the fluid reaches thermal equilibrium

Convection currents in liquids:

-when a part of a liquid is heated,the density decreases because the heated liquid expands.the hot fluid rises up.

-the density of the cooler part of the liquid is now higher than the heated part of the liquid ,so it will sink to replace the position previously occupied by the hotter part of the liquid

-thus,a convection current can be seen in a liquid

Convection current in gas:

-when a part of a gas is heated,it expands and becomes less dense.The hot gas rises up.

-the cooler part of the gas,which has a density higher than the heated gas,will sink

-convection in a gas can be used to explain sea breeze and land breeze

-During day time,the land is heated up faster than the sea -as a result,the air above the land is warmer than above the sea,so it rises up -the cooler and dense air from the sea flows in to replace the rising hot air -the movement of air from the sea to the land is called sea breeze
-At night,the sea loses heat slower than the land -as a result,the air above the sea is warmer than above the land,so it rises up -the cooler and denser air from the land flows towards the sea to replace the rising hot air -the movement of air form the land to the sea is called land breeze

Applications of convection is our daily lives:

Electric kettle	-the heating element is placed at the bottom of a kettle -when electricity is turned on,the heating element heated up water at the bottom -hot water rises up and cold water sinks.thus,a convection current is set up in the kettle -water in the kettle is heated up more uniformly and effectively

Air conditioner	-it is placed at the top of a wall -cold air from the air-conditioner sinks into the room -hot air rises and is cooled by the air conditioner and then sinks down -the cycle is repeated to set up convection currents in the room.hence,the room is cooled efficiently

Radiation(through EM waves)

-radiation is the process of energy transfer by electromagnetic waves
-it can take place without a medium.hence,radiation can take place in vacuum
-the radiation from the sun reaches us in the form of EM waves that travel through a vacuum at the speed of light
-the transfer of energy by EM waves are called electromagnetic radiation
-all objects with a temperature above absolute zero(lowest temperature possible) emits and absorbs EM radiation at the same time.
-when an object emits EM radiation to the surroundings,its temperature falls
-when an object absorbs EM radiation from the surroundings,its temperature rises
-terms that describes objects that emit,absorb or reflect EM radiation
-emitter:any substance that gives off EM radiation
-absorber:any substance that absorbs EM radiation
-reflector:any substance that bounces off EM radiation(which means they cannot absorb radiation effectively)

<u>3 factors that affects the rate of radiation</u>

1:type of surface and color
2.surface temperature
3.surface area

Color and texture of the surface area:
-all objects absorb,emit and reflect radiation in a different rate
-dark,dull(or matte) and rough surfaces are best at absorbing and emitting radiation.they are a poor reflector of radiation
-light-coloured,shiny and smooth surfaces are poor absorbers and emitters of radiation.they are a good reflector of radiation
Surface temperature:
-The higher the temperature of the surface of an object compared to the surrounding temperature,the higher the rate of emission of radiation from the object to the surroundings.
Surface area:
-the larger the surface area if an object,the higher the rate of emission of radiation from the object to the surroundings

Application of radiation:
Greenhouses**:**
-when the sun's radiation is absorbed after entering the greenhouse,it is re-radiated as infrared radiation with longer wavelength that cannot pass through the glass roof easily,so it is trapped and helps us warm the plants in it
Space blanket:
-its shiny and smooth surface helps warm up a person as it is a poor emitter of infrared radiation from the human body to the surroundings
-its shiny and smooth surface is a poor absorber of infrared radiation emitted from nearby forest fires,so it can prevent radiation from reaching and damaging houses when these houses are covered by the space blanket
Global warming:
-when the radiation from the sun enters the atmosphere to warm the earth's surface,the surface absorbs and re-radiates infrared radiation at longer radiation at longer wavelengths
-these longer wavelengths can be absorbed by the atmospheric greenhouse gasses more effectively
-these greenhouse gasses will then reradiate the absorbed radiation in all directions

-some of the radiation escapes into the outer space while the remaining radiation will go through more cycles of re-absorption and re-radiation before returning to the space
-however,more greenhouse gasses are released into the atmosphere through various human activities such as the burning of fossil fuels.as a result,they absorb more radiation and cause the temperature on earth to increase .this is known as the enhanced greenhouse effect.leading to global warming

CHAPTER 9:GENERAL WAVE PROPERTIES

-all waves transfer energy from one place to another without transferring matter

-a wave is defined as a disturbance that propagates through space,transferring energy with it but not matter

-there are two types of waves:

1.mechanical waves-waves that transfer energy through a medium

Eg:sound waves,water waves in a ripple tank and waves on a stretched spring

2.electromagnetic waves– waves that transfer energy without a medium

-the motion of any points in a wave is periodic and repetitive.the motion is known as vibration or oscillation

-periodic motion is motion that repeats at regular intervals

-in mechanical waves,the particles in the medium do not move together with the wave,they remain at their natural positions known as the rest or equilibrium position ,so there is no net transfer of matter at any points of the wave

-they are only temporarily displaced and then return to their rest or equilibrium positions after the wave motion

Wave terms:

1.wave crest:the highest point on a wave

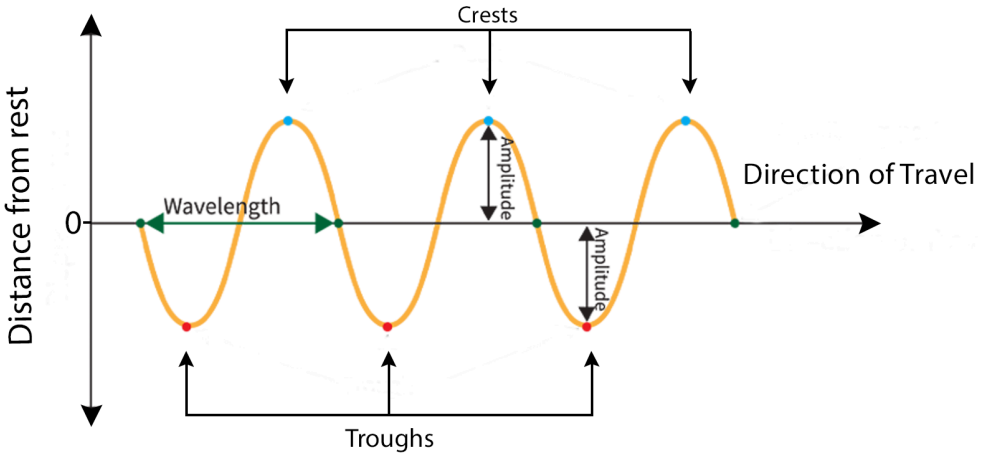
2.wave trough:the lowest point on a wave

3.wavefront:an imaginary line joining all points of the crest(or trough) which have the same phase of vibration

Types of waves:

Transverse waves	Transverse waves are waves which travels in a direction perpendicular to the direction of vibrations	EG:water waves,EM waves
Longitudinal waves	Longitudinal waves are waves which travel in a direction parallel to the direction of vibrations	EG:sound waves

Basic characteristics of waves:



- Displacement is of any point on the wave is a vector pointing from its rest position to the point
- amplitude of a wave is its maximum magnitude of displacement from its rest position
-crests are the highest points of a transverse wave
-troughs are the lowest points if a transverse wave
-wavelength is the shortest distance between two crests or troughs or the start to end point of one successive wave
-it is represented by λ
-its SI unit is meter(m)
-in phase is when any points on the waves have the same direction of motion
-period(T) is the time taken to generate one complete wave
-SI unit is seconds(s)
-the period of a wave can be determined from the displacement time graph
-frequency f is the number of completed waves generated per second
-both frequency and period can be shown in the following formula:

$f = \frac{1}{T}$

f=frequency(Hz)

T=period(s)

-wave speed is the distance traveled by a wave per second

-the SI unit is meter per second(m/s)

-the formula to calculate the wave speed:

$v = \frac{\lambda}{T}$ OR $v = f\lambda$ OR $v = \frac{d}{t}$

v=speed(m/s)

λ=wavelength(m)

T=period(s)

f=frequency(Hz)

d=distance traveled by the wave(m)

t=time(s)

<u>Rarefactions and Compressions</u>

-Rarefactions are particles when they are close together and where air pressure is slightly higher

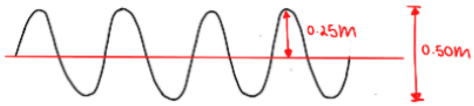
-Compressions are particles when they are further apart and where air pressure is slightly higher

-distance between two compressions or rarefactions=wavelength

(1)

the wave makes a complete up-and-down movement in 0.20s.
the wavelength of this wave shown in the diagram is 1.2m

(a) the amplitude



amplitude = 0.50 ÷ 2
= 0.25m

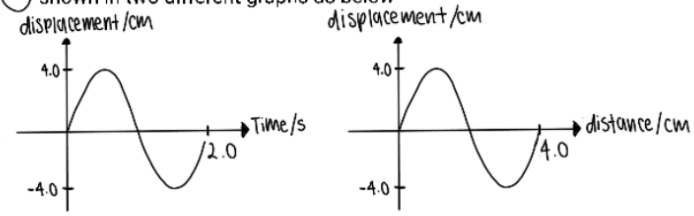
(b) the frequency

$f = \frac{1}{T}$, → period
$= \frac{1}{0.20}$
= 5HZ

(c) the speed of this wave

$V = f\lambda$
= 5 X 1.2
= 6.0m/s

(2) a same wave motion is shown in two different graphs as below

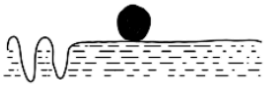


what is the speed of the wave?

$f = \frac{1}{T}$
$= \frac{1}{2.0}$
= 0.5Hz

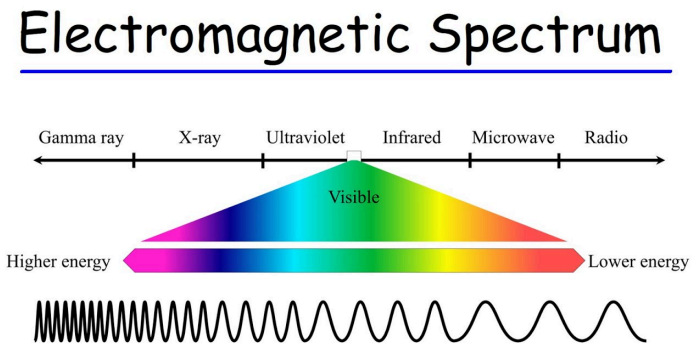
λ = 4cm
V = fλ
= 0.5 X 4
= 2cm/s

a wave moves across the water surface as shown below.
a ball is in the middle of the water



what would happen to the ball when the wave passes?
it moves up and down
water waves are transverse waves and the ball can be used to represent the motion of particles in the water waves

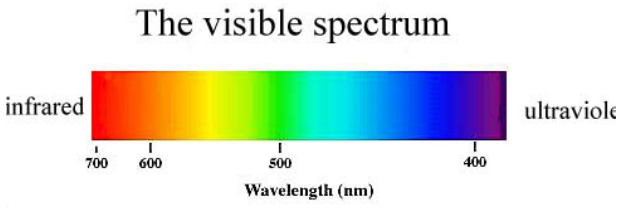
CHAPTER 11 ELECTROMAGNETIC SPECTRUM



-gamma rays,x-rays,ultraviolet,visible light,infrared,microwave and radio
-the seven components of the EM waves are placed according to the wave length and frequency

The 7 waves can be remembered easily by:
Grandma **X**-ercise **U**ntil **V**omit **I**n **M**y **R**oom
-gamma rays have the SHORTEST WAVELENGTH AND HIGHEST FREQUENCY/ENERGY.
-highest frequency=most dangerous
-radio waves have the LONGEST WAVELENGTH AND LOWEST FREQUENCY/ENERGY
-The longer the wavelength,the lower the frequency.Thus,the electromagnetic spectrum wave with the highest frequency will have the shortest wavelength(GAMMA RAYS),and the electromagnetic wave with the lowest frequency will have the longest wavelength.(RADIO WAVES)
PROPERTIES OF THE 7 WAVES:
-they are all transverse waves
-they can travel in a vacuum(no medium needed)
-they have the same speed as light of 3.0x10^8 m/s in vacuum
-they transfer energy from one place to another
-they show wave properties such as reflection and refraction
-they obey the wave equation of $v=f\lambda$

GAMMA RAYS:
-used for radiotherapy
-used for industrial sterilization
X-RAYS:
-used for medical purposes like identifying bone structures
-used for radiation therapy
-used in the airport security systems to detect hidden weapons
-however,it is able to damage living tissues so avoid overexposure
ULTRAVIOLET LIGHT:
-used as fluorescence lamp
-used to sterilize medical equipment
-used as a UV sanitiser
-sunbed(equipment used for sun therapy)
-UV fluorescent security features to detect counterfeit notes
-produce vitamin D in body
-kill bacteria and viruses
VISIBLE LIGHT:



-a wave in the EM spectrum that the human eye can view
-birds and butterflies view the world at 400 frequency(violet)
-snakes and mosquitos view the world at 750 frequency (red)
-there is RED,ORANGE,YELLOW,GREEN,BLU-E,INDIGO and VIOLET
INFRARED:
-detected by specially coded electronic devices and thus,can be used in the above applications
-heat treatment for illnesses
-infrared remote control
-infrared and thermal imaging
-infrared intruder alarm
-infrared thermometer
-can be used for photography through haze and fog.

MICROWAVE:
-used for satellite television
-telephone
-microwave ovens
-microwave and wifi
-microwave and handphone signals
-microwaves and satellite TV
-microcrave and digital TV
RADIO WAVES:
-used to carry messages and simple television pictures over very large distances
-radio communication
-television communication
-the frequency of radio waves can be adjusted ,and by tuning a radio receiver to specific frequency you can pick up a specific signal.
EFFECTS OF EM WAVES ON CELLS AND TISSUES:
-absorption of EM radiation primarily uses heating effects
-over-exposure may result in sunburn or skin cancer
-the higher the frequency,the larger the amount of energy
-ionising radiation:X-rays and gamma rays,some range of the ultraviolet
-ionising radiation that has the energy to remove electrons from atoms or molecules
-exposure to ionising radiation can damage biological molecules and lead to abnormal cell division.it may result in destruction or modification of living tissues
-this may cause cancers and/or deformities to a developing fetus
-non-ionising radiation:low frequency ultraviolet,visible light,infrared,microwave and radiowave.

CHAPTER 13:CURRENT OF ELECTRICITY WORKSHEET 1

STATIC ELECTRICITY

-charges that flows in electric circuit-current electricity

-charges that accumulates on the surfaces of substances(eg:by rubbing electrical insulators vigorously)

TYPES OF CHARGES:

TWO TYPES:positive and negative

-LIKE charges repel,UNLIKE charges attract

UNDERSTANDING CURRENT: I

Definition of current:

Electric current (I) is the rate of flow of charge(Q)

-electric current is when the is a flow of electric charge from one place to another

-if 2C of charge flows through any particular section of the wire every second,we say the current is 2A

Formula for current(I)

I=Q/T

CURRENT(ampere A)

CHARGE(coulomb C)

TIME(seconds S)

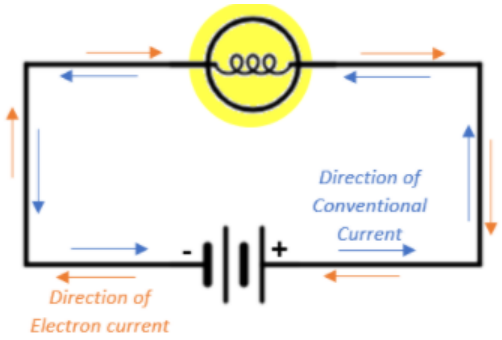
CONVENTIONAL CURRENT AND ELECTRON FLOW:

-in an electric circuit,the current is due to the flow of free electrons.(electrons flow from the negative to positive terminal of the cell)

-direction of a conventional current is taken as the direction a positive charge would flow

-the direction of the conventional current is opposing the direction of motion of electrons

-electrons flow from the negative to the positive terminal of the cell



Measuring electric current:

-ammeter is used to measure the size of an electric current.it must be connected in SERIES to a circuit.

UNDERSTANDING VOLTAGE (V):

-volt (V) is a unit that relates to WORK DONE OR ENERGY

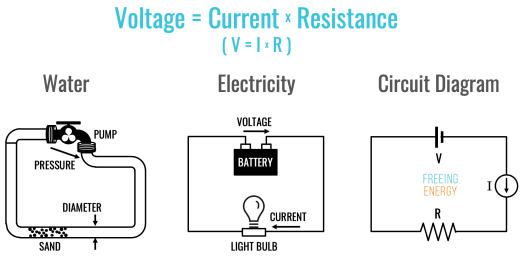
TWO QUANTITIES THAT HAS VOLT AS THEIR UNITS:

1:electromotive force(e.mf)

2.potential difference

Understanding e.m.f

-The electromotive force(e.m.f) of any electrical source is work done by the source in driving a unit charge around a complete circuit.



Water pipe analogy:

-water in horizontal pipe will not flow unless there is a difference in pressure between X and Y

-a water pump is needed to create pressure difference between X and Y before the water can flow

-similarly,a source of energy (cell) is needed to provide the electromotive force to ‘pump’ charge around the circuit

Formula of e.m.f:

$V=\frac{W}{Q}$

V=voltage

W=work done(J)

Q=charge(C)

UNDERSTANDING POTENTIAL DIFFERENCE:

- the potential difference(p.d) across a component in a circuit is defined as the work done to drive a unit charge through the component

-water flows from a region of high pressure to region of low pressure.similarly,the electric charges will flow from a region of high potential to a region of low potential

FORMULA OF POTENTIAL DIFFERENCE:

$V=\frac{W}{Q}$

V=voltage

W=work done(J)

Q=charge(I)

UNDERSTANDING RESISTANCE:

-resistance is the ratio of the potential difference across a component to the current flowing through it

-electrical resistance is a measure of the degree to which an electrical component opposes the pass of an electric current

-resistance is measured in ohm Ω

FORMULA:

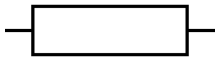
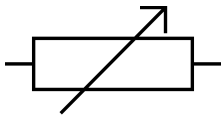
R=V/I

R=resistance(Ω)

V=voltage(V)

I=current(A)

RESISTORS:

Fixed resistors 	-resistance cannot be varied -it is fixed and cannot be adjusted
Variable resistors 	-resistance can be varied -can adjust to specific resistance

Factors that affect resistance

Type of resistivity

-the higher the resistivity,the higher the resistance

Material	Resistivity
copper	1.68×10^{-8}
silver	1.59×10^{-8}
gold	2.44×10^{-8}
aluminum	2.82×10^{-8}
liquid	2.2×10^{-7}
tin	1.09×10^{-7}
tungsten	5.28×10^{-8}
iron	1.0×10^{-7}

2)length of conductor

-the longer the conductor,the higher the resistance

3)cross-sectional area(A)

-the bigger the cross-sectional area,the lower the resistance

FORMULA:

$R=pl/A$

P ↑ R ↑

L ↑ R ↑

A ↑ R ↓

Shortest and thickest wire would have the greatest resistance

Understanding CURRENT I

if 30C of electrical charge flows past a point in a wire in 2 minutes, what is the current in the wire?

$I = \frac{Q}{T} = \frac{30C}{2 \times 60} = 0.25A$

the current in a lamp is 0.2A. if the lamp is switched on for two hours, what is the total electrical charge passing through the lamp?

$Q = IT = 0.2 \times (2 \times 60 \times 60) = 1440C$

it takes 1 hour for 1200C of charge to flow past a point in a wire. what is the current in the wire?

$I = \frac{Q}{T} = \frac{1200C}{60 \times 60} = 0.33A$

the current flowing in a wire is 2A. calculate the total charge flowing past a point in the wire after 30 minutes

$Q = IT = 2 \times (30 \times 60) = 3600C$

Understanding VOLTAGE V

the E.M.F of a dry cell is 2.0V. what is the energy dissipated by the cell in driving 0.5C of charge around the circuit?

$W = VQ = 2 \times 0.5 = 1J$

if the charge 5 X 10^3C flows through an electric heater and the amount of electrical energy converted into heat is 3kJ, calculate the potential difference across the ends of the heater

$V = \frac{W}{Q} = \frac{3 \times 1000}{5 \times 1000} = 0.6V$

a copper wire is connected across the terminals of a battery of E.M.F of 9.0V

(a) what is the electrical energy used to move 50C of charge across the complete circuit

$W = VQ = 9 \times 50 = 450J$

(b)if 30C takes 150s to complete the circuit, determine the current flow

$I = \frac{Q}{T} = \frac{30}{150} = 0.2A$

Understanding RESISTANCE R

an electrical kettle operates 240V and uses a current of 8A. what is the resistance?

$R = \frac{V}{I} = \frac{240}{8} = 30\Omega$

a potential difference of 240V is applied across a resistor of 20Ω. calculate the current flowing across the resistor

$I = \frac{V}{R} = \frac{240}{20} = 12A$

a lamp of resistance 25Ω draws a current 8A. calculate the potential difference across the lamp

$V = IR = 8 \times 25 = 200V$

factors affecting Resistance

X and Y are reels of wire of the same metal. 1m of reel X has a resistance of 5Ω. the wire from reel Y has a cross-sectional area 3 times that of wire from reel X

(a) find the resistance of 5m of wire from reel X

$5 \times 5\Omega = 25\Omega$

(b) calculate the resistance of 1m of wire from reel Y

A ↑ = R ↓ $5\Omega \div 3 = 1.67\Omega$

(c) calculate the resistance of 4m of wire from reel Y

l ↑ = R ↑ $1.67\Omega \times 4 = 6.67\Omega$

CHAPTER 14:D.C CIRCUITS

Series circuits

Current:

-there is only one path for the charges to move in a circuit

-at every point in the circuit,the same amount of charges passing through it

-therefore,the current is the same at every point in a series circuit

-at every point in a series circuit,the current is the same

$I1 = I2 + I3$

-A disadvantage of a series circuit is that if there is a fault at any point of the circuit,it will break the flow of charges,so there will be no current flowing in the circuit.

Potential difference:

-the sum of P.D for the components in a series circuit is equal to the potential difference across the whole circuit

$V = V1 = V2$

Effective resistance:

-for circuits in series,the effective resistance can be calculated by adding all resistors

$R = R1 + R2$

Parallel Circuits

Current:

-there is more than one path for the charges to move in a circuit

-the current from the source is the sum of the currents in the separate branches

$I = I1 + I2 + ...$

-when charges enter a parallel circuit,they can choose which path to take,and it dives among the different branches based on their resistances

-if all paths have the same resistance,charges will be split equally from the main circuit to each path.thus,the current on each path is the same

-if the paths have different resistances,more charges will flow to a path of lower resistance.thus,the current will be greater in the lower resistance path

-as a result,charges split up and flow through different branches simultaneously in a parallel circuit,but the total charge entering the circuit is not lost or gained,adhering to the principle of conservation of charge

-hence,the total current flowing into or out of the parallel branches i equal to the sum of the individual currents in each parallel branch
-an advantage of parallel circuits is that a fault in one parallel path will not affect the circuit in another parallel path

Potential Difference (P.D)

-the potential difference across the separate paths of a parallel circuit is the same as the potential difference of the source
-at each path,the potential difference is the same as the potential difference of the source

$V = V1 = V2$

Effectice Resistance

-for circuits in parallel,effective resistance can be calculated by a formula

$R = (\frac{1}{R1} = \frac{1}{R2})^{-1}$

CHAPTER 15:PRACTICAL ELECTRICITY

Electrical Power

-energy from one energy store can be transferred to another energy store electrically

-all conductors have electrical resistances

-these resistances oppose the flow of charge.as the charges move,they collide with the particles of the conductor

-the particles will vibrate more vigorously which in turn raise the temperature of the conductor

-a metal with high resistance and high melting point is used as the heating element in electrical appliances such as kettles,oven and heater

-in an electric circuit or in a circuit component,power is defined as the rate of change of energy from one form to another

Formula to determine power:

$P = \frac{W}{t} = \frac{E}{t}$ OR $P = VI \ OR \ P = I^2R \ OR \ P = \frac{V^2}{R}$

P=power(W)

W=work done(J)

E=energy(J)

I=current(A)

t=time(s)

-the unit for power is watt(W)

-1W indicates that 1J of electrical energy is converted to other forms of energy in one second

-power can also be defined as the product of the potential difference and the current

Formula to determine electrical energy:

$E = VIt \ OR \ E = Pt \ OR \ E = I^2Rt \ OR \ E = \frac{V^2}{R}t$

Kilowatt Hours

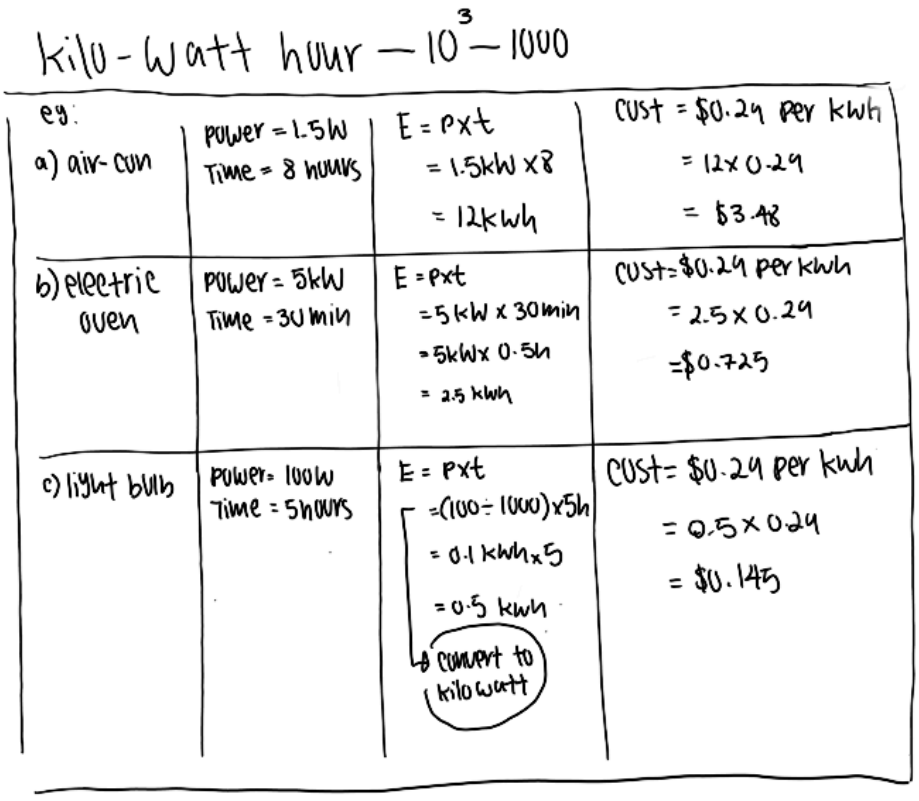
-the amount of electrical energy consumed by any electrical appliance is usually very large

-therefore,the unit for energy used is kilowatt-hours(kWh) instead of joule(J)

-1 kWh indicates the amount of energy consumed by a 1kW appliance in one hour

-steps to determine the cost if electrical energy

Step1	Calculate the energy using E=Pt
Step2	Cost of energy used=energy used(kWh) x unit cost ($/kWh)



Fuse

- a fuse is made out of a piece of tin-coated copper wire
-it is a safety device that protects the wiring and thus protect us
-fuse melts and breaks when current exceeds its specific value
-fuse ratings are 1A,2A,3A,5A,10A and 13A
-when choosing a fuse,the fuse should be able to withstand currents slightly larger than maximum current allowable
-when a short circuit occurs,in an event of a fault,a large current will flow in the circuit due to the presence of low-resistance path.the wire in the fuse melts when current exceeds its rating.this prevents further current flow to avoid overheating of cables and electrical appliances

Switches

-used to turn an electrical appliance on or off

-used as a safety device to cut off flow of current in event someone accidentally touches a live wire and gets an electric shock

-switches are ALWAYS connected to the live wire so that when they are switched off,the electrical appliances can be disconnected from the high voltage

EARTH METAL CASING:(safe use of metal casing)

-earthing,or grounding is a safety measure by connecting metal casing to the appliance to the ground through the earth wire

-earth wire provides a route for the current to flow to the ground if the live wire accidentally touches the metal casing of the appliances

-the earth wire is a low-resistance wire.it provides a low-resistance path for the current to flow to the ground if the live wire accidentally touches the metal casing of the metal appliances.

-there is no need for earth wiring in double insulation(2 pin plug)

Earth wire

-yellow or green

-joined to the metal case of appliance

-if live wire touches case,large current will flow to the earth and blow fuse in live wire

-avoids electric shock

-the earth wire is a low-resistance wire,it provides a low-resistance path for the current to flow to the ground if the live wire accidentally touches the metal casing of the appliances.

Electrical appliance without earth wire	Electrical appliance with earth wire
-when the live wire become lose,it touches the metal casing of the appliance -the metal casing will be at high electrical potential and allows a large current to through it	-when the live wire becomes loose,it touches the metal casing of the appliance. -the earth wire helps divert the current from the metal casing to the ground because it offers a

-when a person touches the metal casing,a closed path may form that allows the current to flow from the mains supply to the ground through the person's body leading to an electric shock	low-resistance path -when a person touches the metal casing,current will not flow through the person because the earth wire has a lower resistance than the person.hence,the person is protected from an electric shock -when the current flowing through the earth wire is 30mA or ore,the ELCB trips and cuts off the electricity supply in the circuit

Live wire

-brown or red

-conducts current from the main supply to the appliances

-all safety devices are connected to the live wire

Neutral wire

-the neutral wire carries the electricity back to the power source.

Double insulation

-in double insulation,electrical appliances are covered with two layers of insulations,such as plastic to ensure electrical safety

-appliances with this feature normally have non-metallic casings,such as plastic casing,and have two-pin plug because they do not have a earth wire

-in double insulation,the internal metal components are covered with the first layer of insulation,such as plastic,to prevent direct contact with the electrical parts.

-a second layer of insulation is provided by the outer non-metallic casings of the appliance,such as plastic

-due to the presence of these two layers of insulation,all exposed metal parts of the metal appliance are effectively insulated and will not become ´live´,reducing the risk of electric shock even if the appliance is faulty

Symbol for double insulation:⧈

Circuit Breakers

-circuit breakers are safety devices that have current ratings

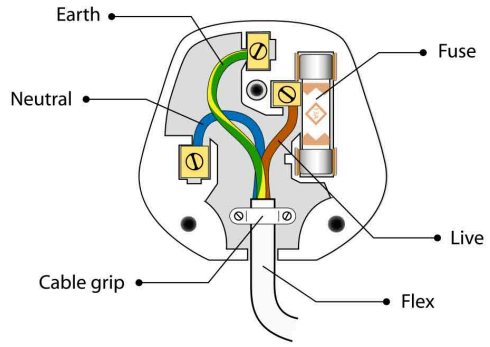
-symbol for circuit breaker:

-they are not added to the plug of an electric appliance.instead,they ar aprt of the main electrical wiring of a house or a room

-a circuit breaker box generally has the following parts:main switch,miniature circuit breakers(MCB) and earth leakage circuit breaker(ELCB)

part	function
Main switch	Turns on and off the electricity supply to the whole house
Miniature circuit breakers(MCB)	Trip and cut off electrical supply to different parts of home circuit during large current surge
Earth leakage circuit breaker	Trips and cuts off electrical supply to the whole house if there is small current leakage from the live write to the earth wire

Wirings in a main plug(three pin)



Type of wire	Colour	During normal functioning	
		Current	P.D
Live	brown/red	Present	High
Neutral	Blue	Present	Low
Earth	Green/yellow	Absent	Low

-a complete circuit is formed by the live and neutral wires only during normal operation
-the live wire conducts current from the mains supply to the appliances
-the neutral wire completes the circuit by conducting current from the appliance back to the mains

Connections of Safety Devices in a Circuit

-safety devices like switches,fuses and circuit breakers must connect to the live wire in the circuit
-the live wire carries both high voltage and the current
-the neutral wire is kept at zero voltage
-by connecting the safety wires to the live wire,they have the capability to cut off current flow and disconnect the live wire from carrying high voltage from the mains in the event of a fault
-if they are connected to the neutral wire,the appliance may still be at risk of being ´live´ even when the circuit is broken at the neutral wire.the user might still get electric shock

CHAPTER 17:RADIOACTIVITY

The atom

-matter is made up of very small particles called atoms

-each atom has a nucleus.most of the mass of atom is contained in the nucleus

-the electrons move around the nucleus rapidly in the electron shells

-an atom is made up of 3 subatomic particles

1)protons-located in the nucleus

2)neutrons-located in the nucleus

3)electrons-circulating around the nucleus(electron shell)

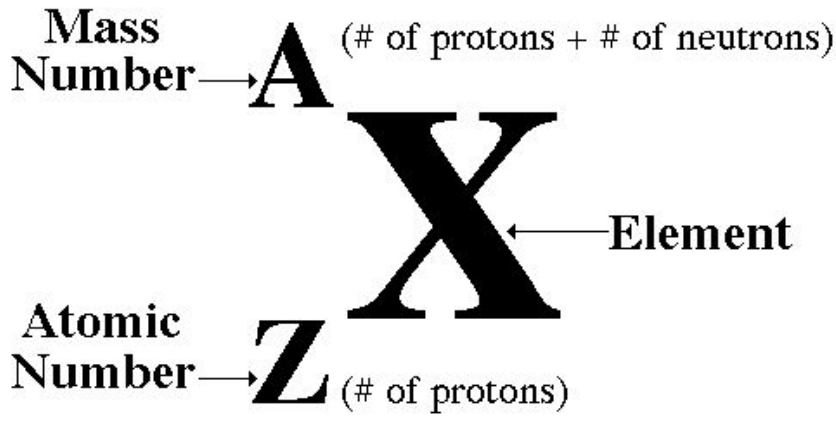
Subatomic particle	proton	Electron	Neutron
Relative mass	1	$\frac{1}{1840}$	1
Relative charge	+1	-1	0(neutral)
Location	Nucleus	Electron shell	Nucleus

-the nucleus of an atom is positively charged due to the presence of protons

-an atom has an equal number of protons and electron.proton=electron

-a nuclide is a type of atom with a particular number of protons and neutrons

-a nuclide can be represented by a nuclide notation that shows the symbol of element,proton(atomic) number or nucleon(mass) number



Isotopes:

-isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons

-isotopes have the same number of proton but different numbers of neutron

-many elements have isotopes.isotopes of the same element have identical chemical properties because the number of electrons do not change thus,same chemical properties as chemical reactions only take place in the electron shell.

Nuclear Decay

-nuclear decay is a random process by which an unstable atomic nucleus loses its energy by emission of electromagnetic radiation or particle(s)

-nuclear decay is also known as radioactive decay or radioactivity which is the process if emitting radiation from unstable atomic nuclei

-some atomic nuclei are not stable because the nuclear forces within the nuclei are not enough to bind the nucleons(protons and neutrons) together

-the radiation emitted by a radioactive nucleus is spontaneous and random

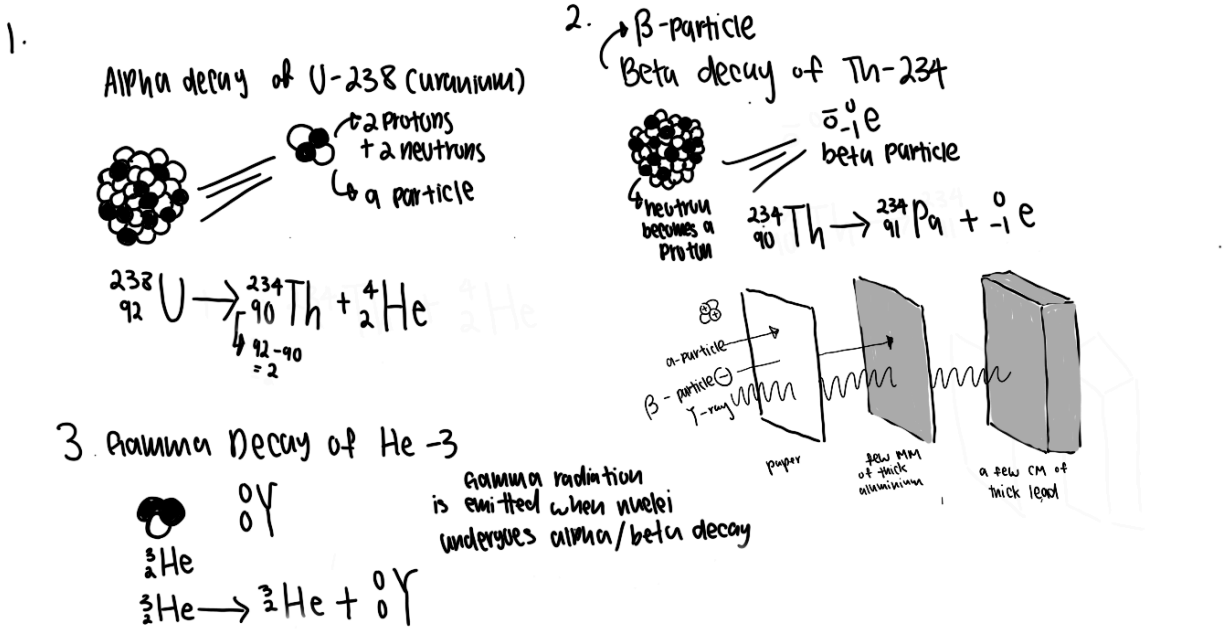
-as a result,the unstable atomic nuclei can emit radiation in three different ways to become more stable

-the three types of nuclear emission have different compositions,ionizing effects and penetrating abilities

-ionization or ionizing effects refers to the ability to eject electrons from atoms to form ions

-penetrating ability refers to the ability to go through matter

Nuclear emission	Nature	Relative ionizing effect	Relative penetrating ability
a-particles	An a-particle consists of two protons and two neutrons tightly bound together	Highest	-least -they are easily absorber by a piece of paper,a thin aluminum foil or human skin
β-particles	β-particle is a fast-moving electron ejected from a radioactive nucleus	Medium	-medium -they are absorbed by a piece of aluminum that is a few millimeters thick
γ-rays	γ-ray is electromagnetic radiation emitted by a nucleus with excess energy	Lowest	-highest -they pass through most materials easily.they are absorbed by lead that is a few centimeters thick or very thick concrete



Background Radiation

-radiation is all around us
-two types of radiation:ionizing and non-ionizing
-non-ionising:microwaves and radio waves
-ionizing radiation(very high frequency):ultraviolet rays,X-rays and gamma rays,are ionizing radiation
-ionizing radiation is radiation with high energies that can knock off electrons from atoms to form ions
-background radiation refers to nuclear radiation in an environment where no radioactive source has been deliberately introduced
-we encounter background radiation every day.the source of background radiation can be artificial or natural

Natural	Artificial
-rocks -cosmic rays -food and drinks high in potassium like bananas,carrots and salt may contain radioactive potassium-40 -radon gas in the air	-medical CT scans -medical X-rays -radiotherapy -building materials and waste products from nuclear power stations

Measuring ionizing nuclear radiation:

-the SI unit of the amount of radioactivity is Becquerel(Bq)

-it refers to the amount of ionizing radiation released when a radioactive atom spontaneously emits electromagnetic radiation as a result of the radioactive decay

-one Bq is equal to 1 disintegration(decay or breakdown)per second.common unit is curie(Ci)

-the measurement of radiation is sometimes expressed as the count rate(counts/min OR counts/s)

-the count rate can be measured using a GM counter

-the count rate decreases when the detector is further away from the source because the radiation becomes more spread out the further away it is from the source

-the background radiation may interfere the actual count rate of a radioactive source.this is because it give reading to the GM tube before the actual count rate of the radioactive source is measured

-when the GM tube is used to detect radioactive emission,the corrected rate of the radioactive source can be obtained by subtracting the background count rate from the count rate measured in the GM tube

Count rate due to BG radiation - count rate measured =corrected count rate of a radioactive sample

Half-life

-the half-life of a radioactive nuclide is the time taken for half the nuclei of that nuclide in any sample to decay

-it means that the number of the radioactive nuclei keeps halving over the same amount of time

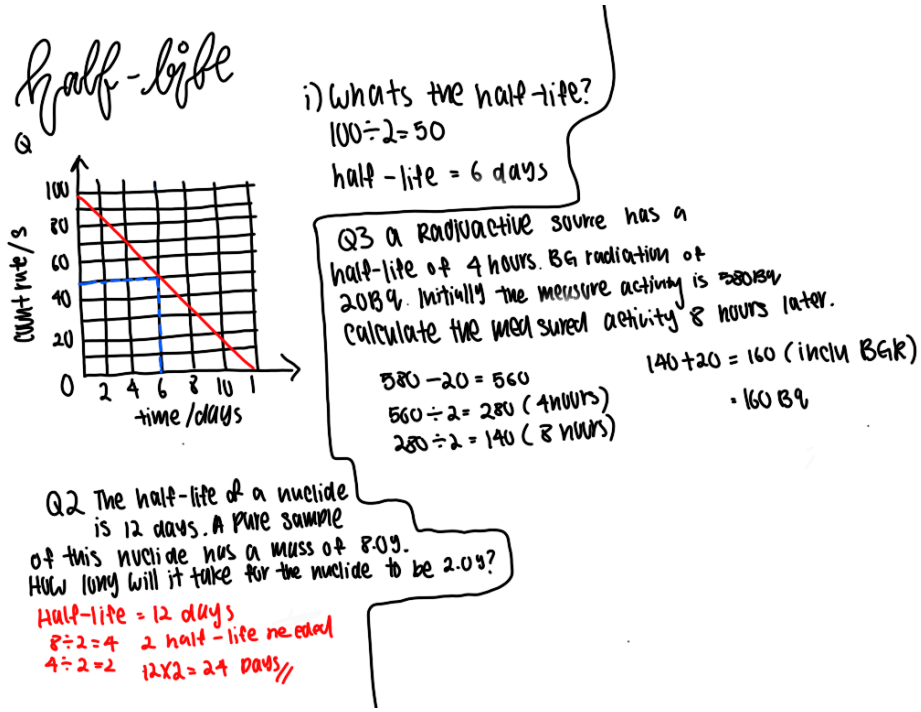
-after each half-life,the number of nuclei remaining in the radioactive source is half of its previous amount

-a graph or flow chart is used to show the halving of the number of nuclei after each half-life

-a graph can also include the constant rate which represents the background radiation

-background radiation must be accounted for when taking readings of a radioactive source.from readings with the source present

-this is known as the corrected count rate



Applications of radioactivity

-radioactive isotopes have many practical uses.the uses can be broadly categorized into:

1.uses related to the damage of cells

2.uses related to radioactive decay and half-life(to determine how old an object is)

3.uses related to the penetrating abilities and ionizing effects

Uses related to the damage of cells:

Nuclear emission	Medical
B-particles	-treatment of thyroid disorder with the help of B-particles emitted by iodine-131

Nuclear emission	Medical	Safety
Y-rays	-y-rays emitted by the isotope,technetium-99, Can detect tumors by producing images of internal organs	-Y-rays can kill microbes in food so that food can last longer and safe for consumption

	-y-rays emitted from the isotope,cobalt-60,can destroy brain tumors -not remain in the human body for too long due to short half-life or these isotopes	-y-rays can sterilize medical equipment such as syringes and scalpers by killing microbes -due to long half-life,only a small a quantity of radioactive substance is needed over a long time/no need to replace frequently as its activity will not drop too fast

Uses related to radioactive decay and half-life

Nuclear emission	Geology
A-particles	-when uranium 238 in rocks undergoes nuclear decay,it emits a-particles and produces lead-206 -hence,the age of rocks can be estimated by counting the relative amounts of uranium-238 and lead-206 in them -the greater the amount of lead-206(or the lower the amount of uranium-238),the older the rock

Uses related to the penetrating abilities and ionising effects:

In industrial:

-use of B-particles and Y-rays

-B-particles of Y-rays are able to penetrate different types of materials

-therefore,they are used to monitor the thickness of material

-B-particles or Y-rays emitted by the radioactive source are detected by the detector.

-hence,by detecting the amount of radiation passing through the material,the thickness of the material can be determined
-the detector will detect a higher count if the material is too thin and a lower count if it is too thick.in this way, a computer will make the proper adjustment to the thickness of the material
-B-particles used in the thin materials like paper
-y-rays used in thick materials liek metal plates ad B-particles cannot pass through thick materials
-a-particles are not suitable because they have a very low penetrating power

In safety:
-use of a-particles
-a-particles have high ionizing ability
-when theta re emitted by americium-241, in the smoke detector,they can ionize the atoms and produce an electric current in the detector
-when smoke enters the smoke detector,it absorbs the a-particles.as a result,the flow of current in the detector is disrupted
-the disrupted of current triggers the detectors alarm
Hazards of radioactivity:
-ionizing radiation can damage human cells and tissues and give rises to different types of cancerous cells
-therefore,we need to handle radioactive sources carefully
-some methods of protection from radioactive sources:
-1.radioactive materials are kept in shielded containers when not in use,for example,lead-lined box
-radioactive materials are handled only when wearing lead-lined gloves and suits to protect our body
-handle the radioactive materials with tongs to increase the distance from them
-the time for using a radioactive source should be limited to reduce exposure time.