Introduction

The purpose of this book is to provide relevant material for each subject in O-level education here in Tanzania. The first edition contains civics, history, geography, biology, chemistry and physics. The content is ordered by syllabus topic and contains relevant definitions and solved problems as they have appeared on NECTA examinations. Though it is impossible to predict NECTA topics and questions, I feel that a student who knows all of the information provided here can get a B in the subject if they are also able to understand English and have competency in the subject material. This is not meant to be a primary resource, but rather it is intended to help guide students and teachers towards relevant topics and questions for study and discussion. This book is for students taking form 4 examinations. Some form 1 and 2 topics are not covered, since they have not appeared on the examinations.

The expectation of this book is that it will provide a base of knowledge that each student will have by the time they come to take their national examinations. In class and in further study, topics and questions can be expanded upon to provide the student with the competency he requires to be successful on his national examinations. Students are encouraged to look at future topics before they are taught in class, so that the teacher can spend class time explaining difficult material, rather than writing definitions or notes on the board.

This work could not have been done without the help of my fellow teachers and staff here at Abbey Secondary School. I am grateful for their contributions to this project. I hope that each year we can update and improve these study guides so that our school can continue to grow academically.

- Jeff Rodwell
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Legal Statement

Additional Credits

Civics - Juma Seif
History - Ramadhani Mndeme
Geography - Field JK Osera
Biology - Gastone Ndunguru
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Physics

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Form 1

1.3.5 Density/relative density

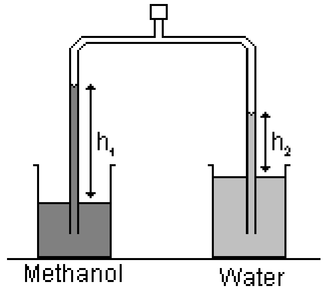
Mass - The quantity of matter in a body. The SI unit is kg
Volume - The amount of space occupied by a substance. The SI unit is m^3, for liquids it is litres (l)
Weight - It is the attractive force towards the earth's center exerted by the earth on the body. Its SI unit is N
Density - The ratio between the mass of an object and its volume
Relative Density - The ratio of the density of a substance to the density of water
Specific Gravity (Relative Density) - The ratio of the density of a substance to the density of a given reference material (i.e. water)
Hydrometer - An instrument used to measure the specific gravity (or relative density) of liquids

Density Equation: $Density(\rho) = \frac{Mass(m)}{Volume(V)}$

Relative Density Equation: $Relative\ Density = \frac{Density\ of\ substance}{Density\ of\ water}$

1. In an experiment using a Hare's apparatus, the lengths of a methanol column and a water column were found to be 16 cm and 12.80 cm respectively

(i) Find the relative density of methanol



Given $h_1 = 16cm$
$h_2 = 12.80cm$
$g = 9.8\ m/s^2$
$\rho_2 = 1g/cm$
$\rho_1 = ?$

At equilibrium: Inside pressure = outside pressure

Step 1: Rearrange for ρ_1	Step 3: Solve for relative density
$\rho_1 h_1 = \rho_2 h_2$ $\rho_1 = \frac{\rho_2 h_2}{h_1}$ **Step 2: Solve for ρ_1** $\rho_1 = \frac{1 \times 12.80}{16}$ $\rho_1 = 0.8 g/cm^3$	$Relative\ Density = \frac{Density\ of\ substance}{Density\ of\ water}$ $RD = \frac{0.8}{1} = 0.8$

(ii) If the length of the methanol column was altered to 21.50 cm, what would be the new height of the water column?

Given: $h_1 = 21.50$ cm
$\rho_1 = 0.8$ g/cm
$\rho_2 = 1g/cm$
$h_2 = ?$

Step 1: Rearrange for h_2	Step 2: Solve for h_2
$\rho_1 h_1 = \rho_2 h_2$ $h_2 = \frac{\rho_1 h_1}{\rho_2}$	$h_2 = \frac{0.8 \times 21.50}{1} = 17.2cm$

1.4.0 Force

1.4.1 Concept of force
Force - Any influence that causes a free body to undergo acceleration
Weight - The product of mass times the weight of gravity (W = mg)

1.4.2 Types of force
Types of force - Attractive force, tortional force (torque), stretching (elastic) force, compressional, repulsive, frictional force
Attractive Force - A force which brings one object towards another
Torque - A force which twists or rotates an object
Elastic Force - A restoring force that returns a body to its original shape
Compressional Force - A force which puts pressure on an object which decreases its size
Repulsive Force - A force which pushes to magnets apart (ex north pole and south pole)
Frictional Force - A force which prevents a body from sliding, opposes its movement

1.4.3 Effects of forces

Effects of forces - Changes the speed of an object, changes the size or shape of an object, changes the direction of movement of an object

1.5.0 Archimedes principle and the law of flotation

1.5.1 Archimedes principle

Archimedes Principle - When a body is partially or totally immersed in a fluid it experiences an upward thrust which is equal to the weight of the displaced fluid

Upthrust - The force exerted by a liquid to a body when the body is partially or totally immersed in water

Opposing forces acting on an object which is totally submersed in water - Upthrust, weight of the object

1. A block of metal of density 2700 kg/m^3 has a volume of 4.0 x $10^{-2}m^3$. Calculate the

(i) Mass of the block

Given: ρ = 2700 kg/m^3

V = 4.0 x $10^{-2}m^3$

Density Equation: $Density(\rho) = \frac{Mass(m)}{Volume(V)}$

Step 1: Rearrange the density equation for mass (m)	**Step 2: Solve for m**
$m = \rho \times V$	$m = 2700 \times (4.0 \times 10^{-2})$ m = **108kg**

(ii) Apparent weight when immersed in brine of density 1200 kg/m^3

Given: V = 4.0 x $10^{-2}m^3$

ρ = 1200 kg/m^3

g = 9.8

Archimedes's Principle: $Upthrust = Weight\ of\ displaced\ fluid$

Archimedes's Principle: $Upthrust = V \times \rho \times g$

$Apparent\ weight = Actual\ weight - Upthrust$

Step 1: Calculate upthrust $Upthrust = (4.0 \times 10^{-2}) \times 1200 \times 9.8$ $Upthrust = 470.4N$ **Step 2: Calculate actual weight** $Actual\ weight = 108 \times 9.8$	$Actual\ weight = 1058.4N$ **Step 3: Calculate apparent weight** $Apparent\ weight = 1058.4 - 470.4$ $Apparent\ weight = 588N$

1.5.2 Law of Flotation

Flotation - A special case when the upthrust is big enough to equal the weight of the object

Law of Flotation - A floating body displaces its own weight of the fluid in which it floats

1.6.0 Structure and properties of matter

1.6.1 Structure of matter

Differentiate between solids, liquids and gases -

	Solid	**Liquid**	**Gas**
Volume	Fixed volume	Fixed volume	Occupies the volume of the container
Motion of Molecules	Molecules vibrate around one position	Molecules move freely within the liquid	Molecules move with high velocity and collide with each other and the wall of the container
Intermolecular Forces	Very strong	Weak	Negligible

1.6.2 Elasticity

Elasticity - The property of a material to return to its original shape and size when the applied force (stretching) is removed

Hooke's Law (of elasticity) - The extension of a spring is in direct proportion with the load added to it as long as this load does not exceed the elastic limit. F = -kx

Coefficient of stiffness - The ratio between tension and extension

1.6.3 Adhesion and cohesion

Adhesion - The attraction process between dissimilar substances (ex. dew on a spider's web)

Cohesion - The attraction process between similar substances (ex. water molecules in a drop)

Mercury has a high cohesive force

1.6.4 Surface tension

Surface Tension - Is the tangential force in the surface acting normally per unit length across any line in the surface

1.6.5 Capillarity

Capillarity - The action of a liquid rising due to adhesion of the molecules

Applications of capillary action - Kerosene rises up a lamp wick, absorption of water by a towel, rising of water from the soil, use of blotting paper on ink

Viscosity - The force of friction which exists between layers of a liquid or gas

Viscous Liquids - Liquids which are difficult to stir and don't flow easily (ex honey, turpentine)

Non-viscous Liquids - Liquids which are easy to stir and flow easily (ex water, kerosene)

1.6.6 Osmosis

Osmosis - Passage of molecules through a semi-permeable membrane from a weak to a strong solution

1.7.0 Pressure

1.7.1 Concept of pressure

Pressure - Is the force acting normally per unit area. Its SI unit is N/m^2 or Pascal

Paschal's Principle of Pressure - When a vessel is completely filled with fluid and pressure is applied at the surface, that pressure is transmitted equally throughout the whole of the enclosed fluid

Devices which apply Paschal's principle - Hydraulic jack, hydraulic press

1.7.2 Pressure due to solids

1. A rectangular wooden block of density 0.8g/cm^3 has dimensions 0.5m x 0.8m x 6m. What is the maximum pressure will it exert on the ground?

Given: ρ = 0.8g/cm^3 or 800kg/m^3
Volume = 0.8 x 0.5 x 6 = 2.4 m^3
g = 9.8

$$density = \frac{mass}{volume}$$

$$weight = mass \times g$$

$$Pressure = \frac{Weight}{Area}$$

Step 1: Calculate mass

$$mass = density \times volume = 2.4 \times 800$$

$$mass = 1920kg$$

Step 2: Calculate weight

$$weight = mass \times g$$

$$weight = 1920 \times 9.8 = 18816N$$

Step 3: Calculate minimum possible area.

This is done because maximum pressure is felt when a body rests on the minimum possible area.

0.5m and 0.8m are the two smallest lengths given

Area = 0.5 x 0.8 = 0.4m^2

Step 4: Calculate the maximum pressure

$$Pressure = \frac{Weight}{Area}$$

$$Pressure = \frac{18816}{0.4}$$

$$Pressure = 47040N/m^2$$

1.7.3 Pressure due to liquids
(Not found in exams)

1.7.4 Atmospheric pressure
Atmospheric Pressure - The pressure caused by the weight of the atmosphere above an object
Barometer - An instrument used for measuring atmospheric pressure

1.8.0 Work, energy and power

1.8.1 Work
Work - Product of the force and distance moved in the direction of the force

1.8.2 Energy
Energy - The quantity which represents the ability to perform work whose SI unit is joules
Types of Energy - Chemical, mechanical, heat, electrical, radiant, kinetic, potential
- **Chemical Energy -** The potential of a chemical substance to undergo a transformation through a chemical reaction to form another substance. The breaking or making of chemical bonds involves absorbing or giving off energy
- **Mechanical Energy -** The sum of potential and kinetic energy in a mechanical system which is associated with the motion or position of an object
- **Heat Energy -** Energy transferred from one body or system to another due to thermal contact when the systems have different temperatures
- **Electrical Energy -** Is the amount of total work that can be done within an electrical system
- **Radiant Energy -** The energy of electromagnetic waves (light)
- **Kinetic Energy -** Energy possessed by a body due to its motion (ex. moving ball)
- **Potential Energy -** Energy possessed by a body due to its position or state (ex. fruit in a tree)

Law of Conservation of Energy - Energy cannot be created or destroyed
Energy transformation examples -
- **Bullet fired from a gun -** Chemical energy from the gun powder is converted into heat energy and then mechanical energy
- **Battery used to light a bulb torch -** Chemical energy in the battery is converted to electrical energy, then heat energy heats the filament and light energy is emitted from the bulb

1.8.3 Power
Power - Work done per unit time

1.9.0 Light

1.9.1 Sources of light
Luminosity - A measurement of brightness
Luminous Bodies - Produce their own visible light (ex sun, some insects, and stars)
Non-luminous Bodies - Cannot produce light on their own. Material that cannot be seen unless they have been illuminated by a luminous body (ex you cannot see humans unless there is light)
Light Ray - The direction of the path taken by light

1.9.2 Propagation and transmission of light
Differentiate between transparency, translucency and opaqueness -
- **Transparency -** The physical property of matter which allows light to pass through a material. Transparent materials are clear (ex. glass)
- **Translucency -** Allows some light to pass through diffusely. Translucent materials cannot be seen through clearly
- **Opaqueness -** No light can pass through the material (ex. metals)

1.9.3 Reflection of light
Reflection - A phenomena in which the light falling on a boundary separating two media is sent back into the first medium
Laws of reflection -
1. The angle of reflection equals the angle of incidence
2. The reflected ray is the in the same plane as the incident ray and to the mirror at the point of incidence

Characteristics of an image formed by a plane mirror - The image or a real object is virtual, a line joining a point on the object and the corresponding point on the image is perpendicular to the mirror, the image is laterally inverted, the image is the same size as the object, the distance of the image from the mirror equals the distance of the image from the mirror

Form 2

2.1.0 Static electricity

2.1.1 Concept of static electricity

Electric Charge (Electrostatic Charge) - A property of matter which causes it to experience a force when near other electrically charged matter
Electrostatic Induction - A redistribution of the electrical charge in an object caused by nearby charges
Electrophorus - A capacitive generator used to produce electrostatic charge by electrostatic induction

2.1.2 Detection of charges

(Not found in exams)

2.1.3 Conductors and insulators

Conductors - Materials which allow electricity to pass through them
Conductivity - Is a measure of a material's ability to conduct an electric current
Insulator - A material which resists the flow of electric current. The electrons in the material are tightly bonded to their atoms
Properties of an Insulator - Valence band and conduction band are far apart, forbidden gap is wide so that electrons cannot gain enough energy to jump across
Explain the following observations -
After a long flight, a plane may become charged - This is due to friction of the metallic body of the plane with the air and clouds

2.1.4 Capacitors

Capacity - The amount of charge a capacitor is able to hold
Capacitor - A device which stores electric charge. It consists of a pair of conductors separated by an insulator. When there is a potential difference (voltage) across the conductors, a static electric field is created which stores energy
Uses of Capacitors - Used for blocking direct current while allowing alternating current to pass, smoothing out power supplies, to tune radios to particular purposes
Capacitance - The measure of the extent to which a capacitor can store a charge
Factors affecting capacitance - Area of the plates, separation distance between the plates, strength of the dielectric material
Essential features of a capacitor - Two conducting plates, an insulator between the plates
Alternating Current (AC) - The movement of electric charge periodically reverses direction
Direct Current (DC) - The unidirectional flow of electric charge (flows only one way)

1. A capacitor is labeled with a capacitance value of 470μF and is charged to a potential difference of 10V. Calculate the charge stored by the capacitor

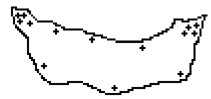
Given: Capacitance, C = 470μF
Voltage, V = 10V
Quantity of charge, Q = ?
Quantity of charge in a capacitor: $Q = CV$

Step 1: Solve for Q	Step 2: Convert μFV into C
$Q = CV$ $Q = 10 \times 470 = 4700\mu FV$	$4700\mu FV = 4.7 \times 10^{-3} C$

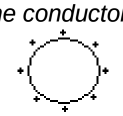
2.1.5 Charge distribution along the surface of a conductor

Lightning Conductor - A metal rod or conductor placed at the top of a building and is connected to the ground through a wire to protect the building from damage caused by lightning

1. Discuss the charge distribution on
(i) The surface of a solid conductor of an irregular shape
The charge density is higher at sharp points than at other areas

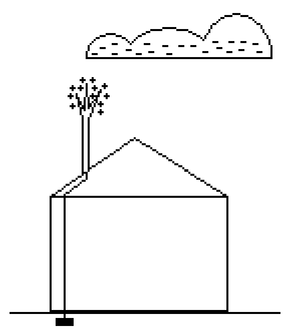


(ii) A hollow conductor
The charge is only on the outside surface of the conductor



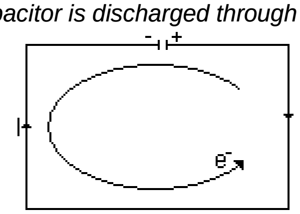
Passengers in the plane are not charged, but an attendant who opens the door is at risk of becoming charged - This is because the inside of the plane is insulated, but when the door is opened the attendant is at risk of touching the body of the plane

(iii) A lightning conductor as clouds pass over spikes on a house
The charge density is higher at the end of the spikes, the cloud is negatively charged and the spikes are positively charged

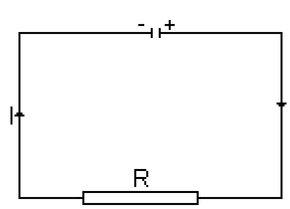


2. (a) (i) What happens when a wire is connected to a charged capacitor? Also draw a diagram showing this.

The electric current flows and the capacitor is discharged through the wire



(ii) An insulated plate A which has a negative charge is joined to a plate B with a positive charge by using a resistance wire. If a charge of 10^{-6}C flows through the wire of resistance 2Ω in 10^{-6} seconds, how much heat is dissipated in the wire?



Given: Energy Formula: $E = \frac{Q^2 R}{t}$

Q = 10^{-6}C
t = 10^{-6}s
R = 2Ω
E = ?

Step 1: Solve for E	
$E = \frac{Q^2 R}{t}$	$E = 10^{-6} \times 2$
$E = \frac{(10^{-6})^2 \times 2}{10^{-6}}$	$E = 2 \times 10^{-6}\ Joules$

2.2.0 Current electricity

2.2.1 Concept of current electricity

Current - A flow of electric charge or the rate of flow of electric charge (SI unit is ampere, and is measured using an ammeter)

Electrical Conduction - The movement of electrically charged particles through a conductor

Measurements used in circuits - Ampere (A), coulomb (C), volt (V), ohm (Ω), watt (W)

- **Ampere (A) -** A steady current which when flowing in two infinitely long, straight, parallel conductors which are 1 meter apart and have negligible areas of cross section cause a force of $2.0x10^{-7}$N per meter between the conductors
- **Coulomb (C) -** The quantity of charge which passes any section of a conductor in one second with a current a one ampere
- **Volt (V) -** The p.d between any two points in a circuit where 1 joule of electrical energy is converted when 1 coulomb passes from one point to another
- **Ohm (Ω) -** The resistance of a conductor through which a current of one ampere is flowing when the p.d across it is one volt
- **Watt (W) -** SI unit of power which measures the rate of energy conversion which is defined as one Joule per second

When an electrical potential difference is placed across a conductor, its movable charges flow, giving rise to an electric current

2.2.2 Simple electric circuits

(Practical use of circuits, discussion of parallel vs series)

**Note that this information is found in section 3.9.0*

2.3.0 Magnetism

2.3.1 Concept of magnetism

Magnetism - A force which is applied at an atomic or subatomic level whereby positive magnets and negative magnets attract one another

Magnet - Is a material or object that produces a magnetic field

Magnetic Materials - Materials which are attracted by a magnet and can be made magnets by artificial methods of magnetization (ex steel, cobalt, nickel, iron)

Nonmagnetic Materials - Materials which are not attracted by a magnet and cannot be magnetized by artificial methods of magnetization (ex wood, carbon, plastic)

Magnetic Field - A field of force produced by a magnetic object or particle or by a changing electric field

Magnetic Pole - A point which exists at or near each end of a magnet at which the attractive forces or repulsive forces of the magnet are concentrated

Single Domain - Refers to the state of a magnet where magnetization does not vary across a magnet

2.3.2 Magnetization and demagnetization

Magnetization - The process causing a material to become magnetic due to an external magnetic field

Methods of making magnets - Stroking, induction, electrical

- **Stroking Method -** One pole of a magnet is rubbed against a metal rod to cause it to magnetize
- **Induction Method -** After a piece of unmagnetized metal is placed near or in contact with a pole of a magnet it will be magnetized

Demagnetization - The causing of a material to lose its magnetic properties due to external forces or through decay over time

Magnetic Induction - The process of producing magnetism in a non-magnetized material when it is placed in a magnetic field

Keepers - Prevents bar magnets from becoming weaker over time due to self demagnetization

Neutral Point - A point in a magnetic field where the resultant field is zero

Reason the strength of a magnet cannot increase beyond a certain limit - When all domains have been oriented in the same direction, no further magnetization is possible which means that the material is saturated

Reason why an increase in temperature weakens or destroyed the magnetism of a magnet - Causes greater atomic vibration which prevents the domain from being aligned in the same direction

2.3.3 Magnetic fields of a magnet

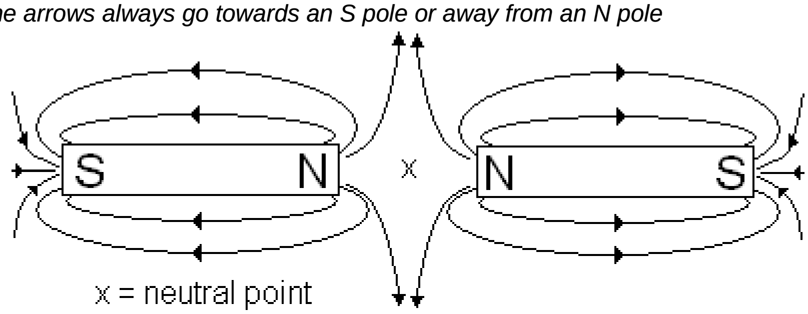
Magnetic Screening - The prevention of a magnetic field from reaching a certain region by surrounding the object with a magnetic material

Magnetic Field - The region around a magnet where the effects of the magnet can be detected

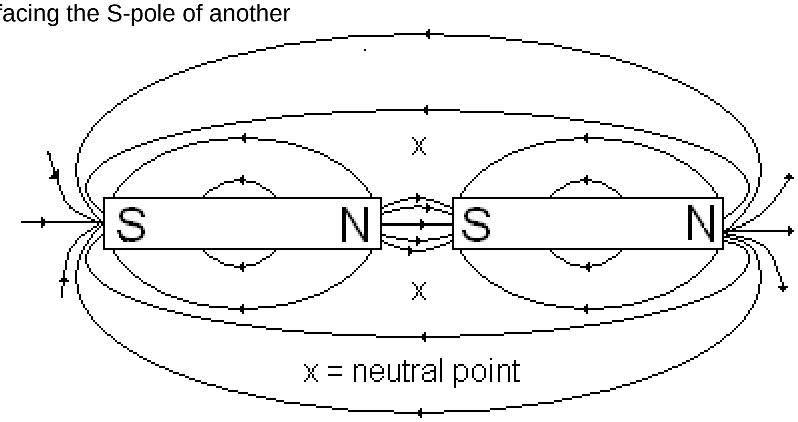
1. Sketch the lines of force between two bars of magnets placed on a horizontal table with:

(i) Their N-poles facing each other

Note that the arrows always go towards an S pole or away from an N pole



(ii) One N-pole facing the S-pole of another



2.3.4 Earth's magnetic field

Earths magnetic field faces <u>north</u>

2.4.0 Forces in equilibrium

2.4.1 Moment of a force

Moment - The tendency of a force to twist or rotate an object (torque). The SI unit is the Newton Metre

Principle of Moments - If a body is in equilibrium under the action of forces which lie in one plane, the sum of clockwise moments is equal to the sum of anticlockwise moments about any point in that plane

2.4.2 Center of gravity

Center of Gravity - A point through which the resultant weight of all particles in the body appear to act

2.4.3 Types of equilibrium

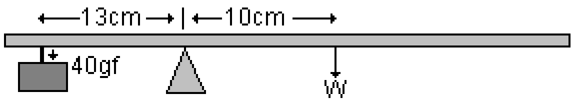
Types of Equilibrium - Stable, unstable, neutral

- **Stable Equilibrium -** When a body returns to its equilibrium position after being displaced slightly (Ex a sphere resting on a concave surface)
- **Unstable Equilibrium -** When a body does not return to its equilibrium position after being slightly displaced (a sphere resting on a convex surface)

Neutral Equilibrium - When a body stays displaced after being slightly displaced and gravity exerts no moment about the base (a sphere on a flat surface)

Why racing cars have wide wheel tracks - Increases stability because a wider base makes it more difficult to turn over

1. A uniform half meter ruler is freely pivoted at the 15cm mark and balances horizontally when a body of mass 40g is hung at the 2.0m mark.
(i) Make a clear sketch to show the forces and their positions in the arrangement



(ii) Calculate the mass of the half-meter ruler

The clockwise moment will be on the right side because it moves the ruler in a clockwise direction. The left side is the anticlockwise moment because it moves the ruler in an anticlockwise direction. The moment is calculated by multiplying the length by the weight for each

Clockwise moment = anticlockwise moment
W x 10cm = 40gf x 13cm
10W = 520
W = 52g

2.5.0 Simple machines

2.5.1 Concept of simple machines

Mechanical Advantage - The factor by which a mechanism multiplies the force or torque applied to it

Mechanical Advantage: $MA = \frac{output\ \ force}{input\ \ force}$

Velocity Ratio (of a machine) - The distance that the point of effort moved divided by the distance that point of load moved

Velocity ratio of a machine: $VR = \frac{distance\ of\ \ effort}{distance\ of\ \ load}$

Efficiency - The ratio between energy used the total energy supplied. The excess energy is wasted, usually as heat energy

Efficiency Equation: $Efficiency = \frac{Energy\ Used}{Energy\ Supplied} \times 100\%$

1. A hydraulic press has a large circular piston of radius 0.8m and a circular plunger of radius 0.1m. A force of 200N is exerted by a plunger.
(i) Find the force exerted on the piston. Also, state one reason why the weight of the load raised by the piston is much less than the force exerted on the piston.

Given: Radius of hydraulic press, R_H = 0.8m
Radius of plunger, R_P = 0.1m
Force of plunger, F_P = 200N
Force of hydraulic press, F_H = ?
Pi = 22/7 or 3.14

Area of a circle: $A = \pi r^2$

Force: $F = P \times A$ or $P = \frac{F}{A}$

Step 1: Calculate areas of the piston and hydraulic press	Step 2: Calculate the power of the plunger
$A_P = \frac{22}{7} \times 0.1^2 = 0.031 m^2$	$P = \frac{F_P}{A_P} = \frac{200}{0.031} = 6451.61 N/m^2$ **Step 3: Calculate F_H**

$A_H = \frac{22}{7} \times 0.8^2 = 2.011m^2$	$F_H = P \times A_H = 6451.61 \times 2.011 = 12974.2\text{N}$

(ii) If the plunger is moved through a distance of 0.64m while exerting its force, what distance will the piston be raised?

Given: Area of hydraulic press, $A_H = 2.011m^2$
Area of plunger, $A_P = 0.031m^2$
Height moved by plunger, $h_P = 0.64m$
Height moved by hydraulic press, h_H = ?
Volume = Area x Height

Since the volume moved by the plunger equals the volume moved by the hydraulic press, we can set up an equation where they are equal to each other and use it to solve for the distance moved by the piston

$$A_P h_P = A_H h_H$$

Step 1: Rearrange for h_H	Step 2: Solve for h_H
$h_H = \frac{A_P h_P}{A_H}$	$h_H = \frac{0.031 \times 0.64}{2.011}$ $h_H = 0.01m$

2.6.0 Motion in a straight line

2.6.1 Distance and displacement

Uniform Velocity - A motion with zero acceleration in a given direction
Uniform Acceleration - A constant rate of change of velocity

2.6.2 Speed and velocity

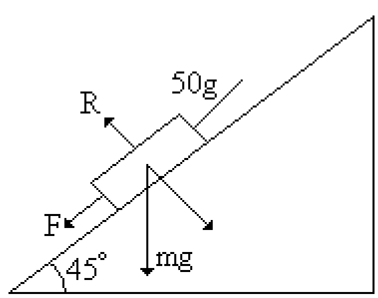
Speed - Is the magnitude of an objects velocity, or the rate of change of an objects position. It is a scalar quantity with an SI unit of m/s
Velocity - Is the measure of the rate of change of an objects position. It is a vector quantity with an SI unit of m/s in a certain direction
Velocity Ratio (VR) - Distance moved by effort per distance moved by load
Terminal Velocity - Occurs when an object's speed is constant due to the restraining force exerted by air (the maximum velocity of a falling object in air)

2.6.3 Acceleration

Acceleration - The rate of change of velocity

2.6.4 Equations of uniformly accelerated motion

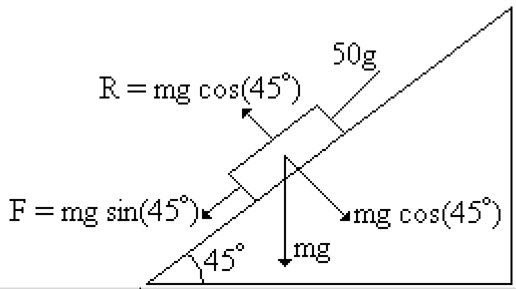
1. 50g mass is placed on a straight track sloping at an angle of 45 to the horizontal as shown in the figure below. Calculate:



(i) The acceleration of the load as it slides down the slope
Given: Mass, m = 55g
Inclination, 45°
Weight parallel to slope, mg sin(45°)
Weight normal to slope, mg cos(45°)

Normal reaction, R = mg cos(45°)
F = mg sin(45°)
g = 9.2 m/s^2
a = ?
Force Law: $F = ma$

First we redraw the picture with this information



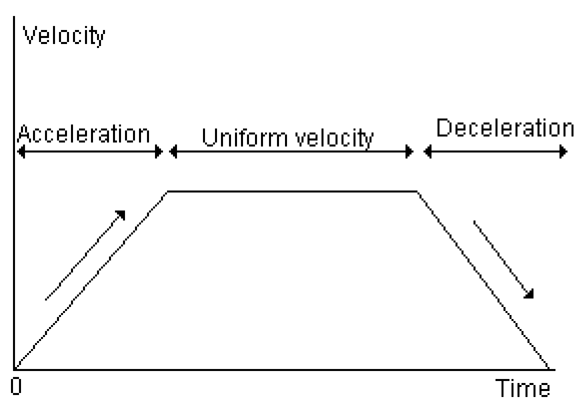
Step 1: Use the force law. *Note that the masses cancel out*	**Step 2: Solve for a**
$mg\sin(45) = ma$	$a = g\sin(45)$ $a = 9.8 \times \sin(45)$ $a = 6.93 m/s^2$

(ii) The distance moved from rest after 0.2 seconds
Given: u = 0
Time, t = 0.2
Acceleration, a = 6.93m/s^2
Distance, S = ?

Distance Equation: $S = ut + \frac{1}{2}at^2$

Step 1: Insert values of variables	**Step 2: Solve for S**
$S = 0 \times 0.2 + \frac{1}{2} \times 6.93(0.2)^2$	$S = 0 + \frac{1}{2} \times 6.93(0.2)^2$ $S = 0.14m$

2. (a) Sketch the diagram of a body which starts from rest and accelerates uniformly for some time to a constant velocity and then maintains this velocity for a certain period of time before decelerating uniformly to a stop.



(b) A car moving with a uniform velocity of 100m/s is decelerated at 2.5m/s to a stop. Calculate:
(i) The time taken for the car to stop

Given: Initial velocity, u = 100 m/s
Final velocity, v = 0 m/s

a = -2.5 m/s^2
t = ?

This is equation means that the final velocity is equal to the initial velocity plus the acceleration over time
v = u + at

Step 1: Rearrange for t	Step 2: Solve for t
$t = \frac{v-u}{a}$	$t = \frac{0-100}{-2.5}$ t = **40 seconds**

(i) The distance traveled by the car before it is brought to rest

Given: $v^2 = u^2 + 2aD$
Distance traveled, D = ?

Step 1: Rearrange for D	Step 2: Solve for D
$D = \frac{v^2 - u^2}{2a}$	$D = \frac{0^2 - 100^2}{2(2.5)}$ D = **2000m**

<u>2.6.5 Motion under gravity</u>
Newton - Unit of force where 1 Newton gives a body of 1kg an acceleration of 1m/s^2
Conditions under which g can denote acceleration or the amount of force -
Acceleration - For gravity g is represented in SI units as m/s^2 under the condition that a body is undergoing free fall
Force - For force g is represented in SI units as N/kg (force (N) per kilogram (kg)), under the condition that the mass is 1kg
Force due to gravity on earth - **9.8 or 10 m/s**

1. (a) A rocket taking off vertical pushes out 25kg of exhaust gas every second at a velocity of 100m/s. If the total mass of the rocket is 200kg,
(i) What is the resultant upward force on the rocket?
Given: m_{rocket} = 200kg
Rate of exhaust flow ($\frac{\Delta m}{\Delta t}$) = 25kg/s
v = 100 m/s
v_o = 0 m/s
Newton's Second Law of Motion: $F = Rate\, of\ change\ of\ momentum$
Newton's Second Law of Motion: $F = \frac{\Delta m}{\Delta t}(v - v_o)$

Step 1: Solve for F. *Note that* $\frac{\Delta m}{\Delta t}$ *is given in the problem as 25kg/s*	$F = \frac{\Delta m}{\Delta t}(v - v_o)$ $F = 25 \times (100 - 0)$ $F = 2500N$

(ii) What is the upward acceleration of the rocket?
Given: F = 2500N
m_{rocket} = 200kg
a = ?
Force Law: $F = ma$

Step 1: Rearrange for a	Step 2: Solve for a

$a = \frac{F}{m}$	$a = \frac{2500}{200}$ a = **12.5m/s^2**

(b) Calculate the acceleration of the rocket in (a) above when it has burned off 100kg of fuel
To find the new mass of the rocket, you subtract the burned fuel from the original mass of the rocket

Given: m = 200kg - 100kg = 100kg
F = 2500N
Force Law: $F = ma$

Step 1: Rearrange for a	Step 2: Solve for a
$a = \frac{F}{m}$	$a = \frac{2500}{100}$ a = **25m/s^2**

2.7.0 Newtons laws of motion

2.7.1 1st Law of motion
1st - Every body persists in its state of being at rest or of moving uniformly straight forward unless it is compelled to change its state by an outside force

2.7.2 2nd Law of motion
2nd - The rate of change of momentum of a body is proportional to the applied force and takes place in the direction of the force

2.7.3 Conservation of linear momentum
Momentum - The product of the mass and velocity of an object. Its SI unit is kg*m/s
Principle of Conservation of Momentum - When bodies in a system interact, the total momentum remains constant provided that no external forces act upon the system
Impulse - The change in momentum of a body when a force has been applied to it. Its SI unit is Ns (Newtons x seconds)

2.7.4 3rd Law of motion
3rd - To every action there is an equal and opposite reaction

2.8.0 Temperature

2.8.1 Concept of temperature
Temperature - A quantitative measurement of hot or cold. Its SI unit is Kelvin (K)
Absolute Zero - The temperature at which atoms stop moving, thereby causing the volume of a gas to drop near zero. It is measured as 0K

2.8.2 Measurement of temperature
Thermometer - An instrument which measures temperature
Fundamental Interval of a Temperature Scale - The difference in temperature between the upper fixed point and the lower fixed point
- **Upper Fixed Point -** The temperature of steam from water boiling under standard atmospheric pressure of 760 mmHg
- **Lower Fixed Point -** The temperature of pure melting ice under standard atmospheric pressure of 760 mmHg

Advantages of mercury over alcohol as a thermometric liquid - Does not vaporize easily, expands steadily, Hg is a better conductor of heat, has a higher boiling point, does not cling to the glass inside the thermometer, it is opaque and easier to read
Similarities between maximum and minimum thermometers - Perform one way measurement, contain steel indices
Differentiate between maximum and minimum thermometers -
- **Maximum Thermometer -** Records the maximum temperature reached during a certain period of time. It uses mercury in a glass thermometer

Minimum Thermometer - Records the minimum temperature reached during a certain period of time. It uses alcohol in a glass thermometer

1. Determine the final temperature obtained when 500g of water at 100°C was mixed with 500g of water at 10°C and well stirred (Note: The specific heat capacity of water is 4200 J/(kg°C)
NECTA 2007 4c

Note that since the masses of the two samples of water are the same, you can just average the temperatures to get 55°C ((100+10)/2)

2.9.0 Sustainable energy sources

2.9.1 Water/solar/wind/sea/geothermal energy

Types of renewable energy - Wind, geothermal, solar, sea wave
- **Wind Energy -** Energy derived from the Earth's winds
- **Geothermal Energy -** Energy derived from the internal processes of a planet
- **Solar Energy -** Energy derived from a stars radiant energy
- **Sea Wave Energy -** Energy derived from waves in the oceans
- **Water Energy -** Energy derived from falling water (ex. HEP)

Anemometer - An instrument used for measuring wind speed
Wind Vane - An instrument used for showing the direction of the wind

Form 3

3.1.0 Applications of vectors

3.1.1 Scalar and vector quantities

Scalar Quantity - A quantity which is not associated with a direction
Vector Quantity - A quantity which is associated with a direction
Speed vs. Velocity -
- **Speed -** Refers to the distance covered per unit of time without specifying direction (scalar)
- **Velocity -** Refers to the distance covered in a given direction per unit of time (vector)

3.1.2 Relative motion

Relative Velocity - The vector difference between two velocities of two objects

3.1.3 Resolution of vectors

Resolution of vectors - To resolve vectors into two components (vertical and horizontal)
Parallelogram Law of Forces - If two forces are represented in magnitude and directions by an adjacent side of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram
Triangle Law of Forces -
(Add vector problems)

3.2.0 Friction

3.2.1 Concept of friction

Friction - The force resisting motion between surfaces which are sliding against each other by converting kinetic energy into heat (ex a block moving down an inclined plane)
Coefficient of friction - A scalar quantity which describes the ratio of the force of friction between two bodies and the force pressing them together
Ways of reducing friction - Using a lubricant like oil/water/grease between two solid surfaces, streamlining, polishing surfaces, separating surfaces by air, uses rollers or ball bearings
Advantages of friction - Allows walking, cars can brake, used to for parachutes
Limiting Friction - The maximum value of frictional force exerted between two surfaces not moving relative to each other
(Add friction problems)

3.2.2 Types of friction

Types of friction - Dry, fluid, lubricated, skin, internal

Dry - Resists relative lateral motion of two solid surfaces in contact
Fluid - Friction between layers within a viscous fluid that are moving relative to each other
Lubricated - Friction which occurs when a fluid separates two solid surfaces (ex oil in a motor)
Skin - The force resisting the motion of a solid body through a fluid
Internal - The force resisting motion between elements of a solid material as it deforms

3.2.3 Laws of friction

Laws of Friction -

Amontons' 1^{st} Law - The force of friction is directly proportional to the applied load
Amontons' 2^{nd} Law - The force of friction is independent of the apparent area of contact
Coulomb's Law of Friction - Kinetic friction is independent of the sliding velocity

3.3.0 Light

3.3.1 Reflection of light from curved mirrors

Concave Mirror - Has a reflecting surface that bulges inward (away from the incident light) and reflect light inward to one focal light (they focus light)
Convex Mirror - A mirror in which the reflective surface bulges towards the light source, scattering the light
Plane Mirror - A flat mirror
Principle Focus - The point where light rays originating from a point on an object converge with one another
Incident ray of light - The ray of light leaving the mirror after reflection
Radius of Curvature - The distance from the vertex to the centre of curvature of the surface
Principle Axis - The main axis of the lens or mirror
Pole - A point that describes the position and orientation of a line with respect to a given circle
Differentiate between real and virtual images -

Real Image - A representation of an object in which the perceived location is actually a point of convergence of the rays of light that make up the image (ex. images on a cinema screen)
Virtual Image - An image in which outgoing rays from a point on the object always intersect at a point (ex. an image in a flat mirror)

Characteristics of an image formed by a convex mirror - The image is virtual, erect and smaller than the object, except if the object is closer than the focal point
Characteristics of an image formed by a concave mirror - The image is always real except when the object is between the focal point and the mirror, the image is always inverted, the size depends on the distance from the mirror
Position of an image in a concave mirror of a distant object - It is formed at the principle focus

Lens Formula: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

3.3.2 Refraction of light

Refractive Index - The ratio of the speed of light to the medium
Refraction - A change in the direction of a wave due to a change in its speed. For light it is the change of speed of light (and hence its direction) due it entering a different medium
Total Internal Reflection - An optical phenomenon which occurs when a ray of light strikes a medium boundary at an angle larger than the critical angle with respect to the normal to the surface. If the refractive index is lower on the other side of the boundary, no light can pass through and all of the light is reflected
Angle of Incidence - The angle formed between the incident ray and the normal a the point of incidence
Normal (to a flat surface) - Is a vector that is perpendicular to that surface
Critical Angle - The angle of incidence above which total internal reflection occurs. It is measured with respect to the normal
Conditions necessary for total internal reflection - Light must be passing from a dense medium to one which is less dense, the incident light must be greater than the critical angle of the medium
Conditions giving rise to a critical angle - Light travels from a dense medium to one which is less dense and is refracted at 90°
Cause of refraction of light when passing through transparent media - This is due to the fact that light changes velocity when moving from one medium to another
Mirage - A naturally occurring optical phenomenon where light rays are bent to produce a displaced image of distant objects or the sky

Why a swimming pool appears shallower than its depth - It happens because light rays bend as they pass from water to air. When they pass from water to air, they are reflected with an angle of refraction greater than the angle of incidence

1. Three slabs of different types of glasses are placed on a table one on top of the other in the following order from below:

Slab	Refractive Index	Thickness
A	1.4	1.2cm
B	1.5	1.8cm
C	1.6	0.8cm

Where will the mark on the table appear to be?

Given: $\mu_A = 1.4$
$\mu_B = 1.5$
$\mu_C = 1.6$
$D_A = 1.2cm$
$D_B = 1.8cm$
$D_C = 0.8cm$
D represents real depth and d represents apparent depth

Real Depth: $\mu = \dfrac{Real\ depth(D_a)}{Apparent\ depth(d_a)}$

$$Position = Total\ real\ depth - Total\ apparent\ depth$$

$$\mu_A = \frac{D_A}{d_A}$$

Step 1: Rearrange for d_A

$$d_A = \frac{D_A}{\mu_A}$$

Step 2: Solve for d_A, d_B and d_C

$$d_A = \frac{1.2}{1.4} = 0.86cm$$

$$d_B = \frac{1.8}{1.5} = 1.2cm$$

$$d_C = \frac{0.8}{1.6} = 0.5cm$$

Step 3: Solve for position

$$Position = Total\ real\ depth - Total\ apparent\ depth$$

$$Position = (1.2 + 1.8 + 0.8) - (0.86 + 1.2 + 0.5)$$

$$Position = 1.24cm$$

<u>3.3.3 Refraction of light by a rectangular prism</u>
(Not found in exams)

<u>3.3.4 Refraction of light by a triangular prism</u>
(Not found in exams)

<u>3.3.5 Colours of light</u>

Primary Colours - Sets of colours which can be combined to make a useful range of colours
Secondary Colours - A colour made by mixing two primary colours
Complimentary Colours - Colours which when added together form white light
Additive Colour - The use of red, green or blue light to produce other colours by combining them together. This is used in projectors
Subtractive Colour - The colour that the surface displays are the colours which are reflected by the material. This is used in the mixing of paints, dyes and inks. The colours used are generally cyan, magenta and yellow
Chromatic Aberration - A type of distortion in which there is a failure in the lens to focus all colours to the same convergence point due to lenses having different refractive indexes for different wavelengths of light
Fluorescence - The emission of light by a substance that has absorbed light or other electromagnetic radiation of a different wavelength

Why objects appear coloured - An object with colour tends to reflect light of its colour and absorbs the rest. The colour seen by a person is the colour which was reflected back

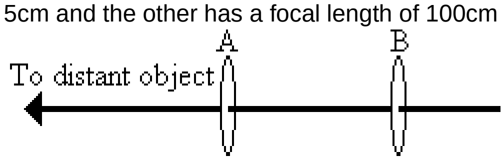
Why mixing two paint colours is different than mixing two of the same colours of light (ex blue and yellow) - Pigments in paint absorb light, so the yellow pigment will absorb blue light and reflects yellow/red/green, while the blue pigment absorbs yellow and red light and reflects blue/green. Since the only common colour between the two that is being reflected is green, the colour reflected will be green (this is mixing by subtraction). Blue and yellow light are complementary colours so they add to form white light (this is mixing by addition)

3.3.6 Refraction of light by lenses

Principle focus of a convex lens - The point on the principle axis where all rays originally parallel and close to the axis converge

Cause of a blurred image in a concave mirror or convex lens - This is caused by light rays not coming together at the same focus

1. (a) In the following figure are two convex lenses correctly set up as a telescope to view a distant object. One lens has a focal length of 5cm and the other has a focal length of 100cm



(i) What is A called and what is its focal length?

A is called the objective lens and has a focal length of 100cm. The objective lens has a longer wavelength than the eyepiece lens

(ii) How far from A is the first image from the distant object?

The image of the distant object is formed at the focus which is 100cm

(iii) What is the name of B?

Eyepiece lens

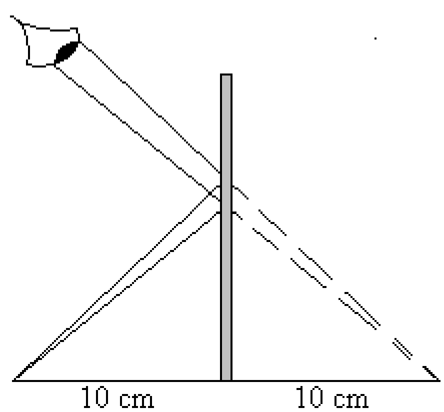
(iv) What acts as the object for B and how far must B be from it if someone is looking through the telescope wants to see the final image at the same distance as the distant object?

The image of A acts as the object for B and therefore must be at the focus of B which is 5cm away

(v) What is the distance between A and B with the telescope set up in part iv?

The distance between A and be is the sum of their focal lengths, 100cm + 5cm = 105cm

(b) Show by a ray diagram how a suitable placed eye sees an image of a point object which is placed 10cm in front of a plane mirror. Show clearly the position of the image and give two reasons why it is a virtual image.



This image is virtual because it cannot be formed on the screen and there is no actual intersection of light rays when the image is formed

(c) Calculate the critical angle for light emerging from glass of refracting index 1.55 into air

Given: Refractive index, ${}_g\eta_a$ = 1.55

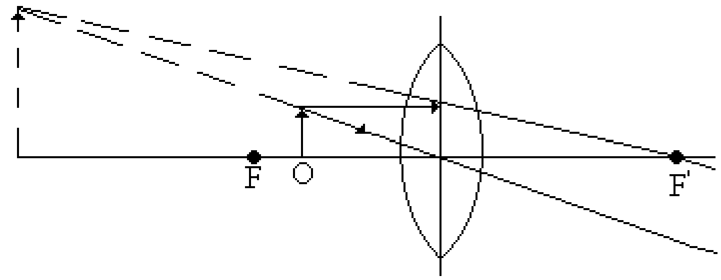
r = 90°

Critical angle, c = ?

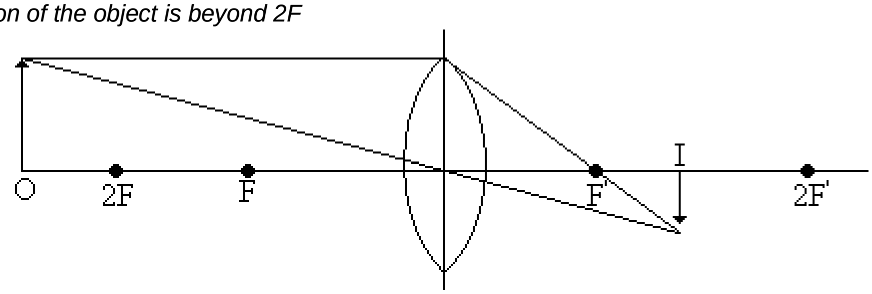
Critical Angle: ${}_g\eta_a = \dfrac{\sin c}{\sin r}$

Step 1: Rearrange for sin c	Step 2: Solve for the angle
$\sin c = \frac{\sin r}{_a\eta_g} = \frac{\sin 90}{1.55} = 40.2^o$	$\sin c = \frac{\sin 90}{1.55} = 40.2^o$

2. (a) Explain with ray diagrams the use of the following lenses
(i) As a magnifying glass
Convex lens
The position of the object (O) is between the principle focus (F) and the lens



(ii) In a camera
Convex lens
The position of the object is beyond 2F



(b) State the characteristics of the images formed in (a) above
(i) The *image is virtual, larger than the object, on the same side as the object and is erect*
(ii) *The image is real, smaller than the object, between F and 2F and is inverted*

3. A screen is placed 80 cm from an object. A lens is used to produce on the screen an image with a magnification of 3. Calculate the
(i) Distance between the object and the lens

Given: Magnification = 3
u is the object distance, v is the image distance from the lens
u + v = 80cm

Step 1: Solve for v	Step 2: Solve for u by substituting v
$m = \frac{v}{u}$ $3 = \frac{v}{u}$ $v = 3u$	u + v = 80cm u + 3u = 80cm 4u = 80cm u = **20cm**

(ii) Focal length of the lens

Given: Lens Formula: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

u = 20cm
v = 3u (from above) = 3*20 = 60cm

f = ?

Step 1: Insert v into the equation	
$\frac{1}{f}=\frac{1}{u}+\frac{1}{3u}$	$\frac{1}{f}=\frac{3}{60}+\frac{1}{60}$
Step 2: Insert values of u and 3u	**Step 4: Cross multiply**
$\frac{1}{f}=\frac{1}{20}+\frac{1}{60}$	$\frac{1}{f}=\frac{4}{60}$
Step 3: Add the fractions	$4f=60$ $f=15cm$

4. A telescope of 5m diameter reflector of focal length 18.0m is used to focus the image of the sun. Using the distance of the sun from Earth and the diameter of the sun as 1.5×10^{11}m and 1.4×10^{9}m respectively, calculate the diameter of the image of the sun

Given: Object distance, u = 1.5×10^{11}m
Object diameter, d = 1.4×10^{9}m
Focal length, f = 18m
v = f = 18m

Magnification Equation: $\frac{Image\ distance}{Object\ distance}, m=\frac{v}{u}$

First you need to find the magnification
Step 1: Solve for m

$$m=\frac{18}{1.5\times10^{11}}$$

m = 1.2×10^{-10}

Now you can find the diameter of the sun
Given: d = 1.4×10^{9}m
m = 1.2×10^{-10}
d' = ?

Magnification Equation: $\frac{Image\ diameter}{Object\ diameter}, m=\frac{d'}{d}$

Step 1: Rearrange for d'	Step 2: Solve for d'
$d'=m\times d$	$d'=(1.2\times10^{-10})\times(1.4\times10^{9})$ d' = **0.168m**

3.4.0 Optical instruments

3.4.1 Simple microscope
(Not found in exams)

3.4.2 Compound microscope
(Not found in exams)

3.4.3 Astronomical telescope
Physics principles used to make telescopes - Reflection, refraction

3.4.4 Projection lantern
(Not found in exams)

3.4.5 The lens camera
Differentiate between images formed in plane mirrors and a pinhole camera -

Plane Mirror	Pinhole Camera
• Image is virtual • Image is the same size as the object • Image is laterally inverted • Image is as far from the mirror as the actual object is	• The image is real • The image is smaller in size (scaled) • Image is vertically inverted • Image distance is determined by the length of the box

3.4.6 The human eye
(Not found in exams)

3.5.0 Thermal expansion

3.5.1 Thermal energy
Heat - The energy transferred from one body to another due to contact when they are at different temperatures
Sources of heat in daily life - The sun, electric circuits (in appliances), engines, our bodies
Differentiate between heat and temperature -

Heat	Temperature
• The amount of internal energy possessed by a body • Flows from a point with high temperature to one with a low temperature • Measured in Joules (J)	• Is the measure of hotness or coldness of a body • Does not flow, varies as the quantity of heat in the body or substance varies • Measured in Celsius (°C), Fahrenheit or Kelvin

3.5.2 Thermal expansion of solids
Coefficient of Linear Expansion - Fractional change in linear dimensions (length/radius) per unit temperature change (°C or °K). Its SI unit is length / °C

3.5.3 Thermal expansion of liquids
Apparent Expansivity of Water - The fractional increase in volume of water as it expands due to a temperature rise in a heated vessel
Anomalous Expansion of Water - The tendency of water to expand as it is cooled below 4°C

3.5.4 Thermal expansion of gases
Ideal Gas - A theoretical gas composed of a set of randomly moving particles which obeys the ideal gas law
Ideal Gas Law - The equation of a state of a hypothetical ideal gas which approximates the behaviour of many gases under varying conditions combining Boyle's Law and Charles's Law
Boyle's Law - Describes the inversely proportional relationship between pressure and volume of a gas (as volume increases, pressure decreases)
Charles's Law - A law which describes how gases tend to expand when heated, showing the direct relationship between temperature and volume (as temperature increases, volume increases)
Kinetic Theory of Gases - Explains the behaviour of gases based on the movement of their molecules
Avagadro's Hypothesis - Requires that equal volumes of all ideal gases have the same number of molecules at STP
Why gases have pressure - When gases travel in a container they hit the walls which exert a force on the walls (pressure) As the temperature rises, the molecules move faster, thereby hitting the wall more often which increases the pressure. As the temperature decreases, the molecules move slower and hit the wall less often which decreases the pressure
Why diffusion happens in gases - Molecules in gas move randomly and when they collide with each other, they bounce in different directions. This causes molecules to move from areas where there are a lot of collisions to areas where there are very little collisions (moving from an area of high concentration to an area of low concentration)

3.6.0 Transfer of thermal energy

3.6.1 Conduction of heat
Thermal Conduction - The transfer of thermal energy between neighbouring molecules in a substance due to differences in temperature
Thermopile - An electronic device that converts thermal energy into electrical energy

Good conductors of heat - Metals like copper, aluminum, iron, silver, led
Bad conductors of heat - Nonmetals like diamonds, rubber, glass, cork, paper

3.6.2 Convection

Convection - The movement of molecules within liquids or gasses
Kinetic Energy - The energy possessed by a body due to its motion
- **How kinetic energy is related to temperature of gases -** The kinetic energy of gas molecules is proportional to the temperature of the gas

3.6.3 Radiation

Thermal Radiation - Electromagnetic radiation emitted from a material due to its temperature
Good emitters/absorbers of radiant heat - Things with dark colour, metals like copper, iron, silver, led
How heat loss in a thermos flask is prevented -
- **By Conduction -** The flask is made of glass which is a poor conductor of heat, the stopper is made of wood/rubber/cork which are bad conductors of heat, the supporting pad is made of rubber which is a poor conductor of heat
- **By Convection -** There is a vacuum between the walls of the flask. Also by closing the flask at the top by using a stopper
- **By Radiation -** Using silvered walls to reflect infrared radiation back into the thermos flask

3.7.0 Measurement of thermal energy

3.7.1 Heat capacity

Specific Heat Capacity - The measurable physical quantity for the amount of heat required to change a body's temperature by a given amount. Its SI unit is joules per Kelvin (J/K)
Differentiate between heat capacity and specific heat capacity -
- **Heat Capacity (Thermal Capacity) -** The amount of heat required to raise its temperature by 1K
- **Specific Heat Capacity -** Heat required to raise the temperature of a unit mass of the substance by 1K

Explain the following observations -
- **Gas thermometers are more sensitive and accurate than liquid thermometers -** This is due to gases having a lower specific heat capacity than liquids
- **Alcohol is used in glass thermometers in Arctic regions -** This is due to alcohol having a lower freezing point than mercury
- **A house with thick walls is likely to be cooler during the hot season -** This is because a thick wall will conduct less heat from the outside into the house
- **Level of liquid being heated in a vessel first falls before starting to rise -** This is because the vessel expands first, which increases the internal volume, causing the liquid to fall

Linear Expansivity - The faction of its original length by which a rod of the substance expands per Kelvin rise in temperature
Coefficient of Linear Expansivity - The fractional increase in length per degree centigrade rise in temperature
Applications of Bimetallic Strips - Making thermostats, bimetallic thermometers, indicators

1. 200g of a liquid at 21°C is heated to 51°C by a current of 5A at 6V for 5 minutes. What is the specific heat capacity of the liquid?

Given: m = 200g or 0.2kg
Initial temperature = 21°C
Final temperature = 51°C
I = 5A
V = 6V
t = 5 min or 300s
Heat gained by a liquid = $mc\Delta\theta$
Heat supplied by a current = IVt
Heat supplied = Heat gained

First we calculate the heat gained, then heat supplied and then we can solve for the heat capacity

Step 1: Calculate heat gained
$mc\Delta\theta$

$5\times6\times300=9000J$
Step 3: Solve for heat capacity (c)
Heat supplied = Heat gained

$$(0.2)\times c\times(51-21)=6c\ kg\,^{o}C$$

Step 2: Calculate heat supplied

$$IVt$$

$$6c=9000$$

c = **1500 J/kg°C**

2. A tin contains water at 290K and is heated at a constant rate. It is observed that the water reaches boiling point after 2 minutes and after another 12 minutes it is completely boiled away. Calculate the specific latent heat of the steam

Given: T_1 = 290K
Boiling point of water = 373K
Time to reach boiling point, t_1 = 2 min
Time to boil away, t_2 = 12 min
Specific heat capacity of water, c = 4200 J/kgK
Specific latent heat of steam, L = ?
Heat gained by a liquid = $mc\Delta T$

$$Power=\frac{Heat}{t}$$

$$Power\times t=m\times L$$

Note that the mass of the water (m) will cancel out, since mass is not important in finding the specific latent heat of a substance. The specific latent heat will be the same no matter what the mass is

Step 1: Solve for heat

$$mc\Delta T$$

$$m\times 4200\times(373-290)=348600m\ J$$

Step 2: Solve for power

$$Power=\frac{Heat}{t}$$

$$Power=\frac{348600m}{2}=174300m\ J/\min$$

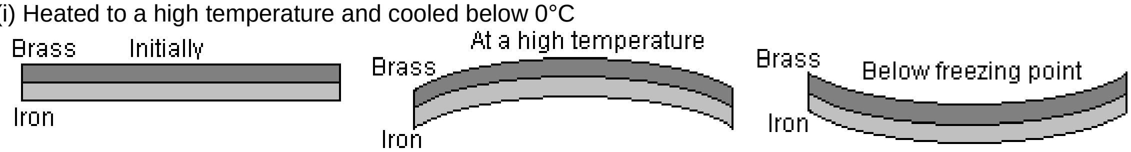
Step 3: Solve for specific latent heat (L). *Note that the masses cancel out during this step*

$$Power\times t=m\times L$$

$$174300m\times 12=m\times L$$

L = 2,091,600 J/kg

3. (a) A compound strip of brass and iron is straight at room temperature. Draw a labeled diagram to show its appearance when it has been:
(i) Heated to a high temperature and cooled below 0°C



(b) A compound strip of brass and iron 10cm long at 20°C is held horizontally with iron on top. When heated from below by a Bunsen burner, the temperature of the brass is 820°C and the iron is 770°C. Calculate the difference in lengths of the iron and brass

Given: L_o = 10cm
$\alpha_B = 1.9\text{x}10^{-5}$
L_{Bo} = 10cm
ΔT_B = 820 - 20 = 800°C
$\alpha_I = 1.2\text{x}10^{-5}$
L_{Io} = 10cm
ΔT_I = 770 - 20 = 750°C

Linear coefficient of expansion: $\alpha=\dfrac{\Delta L}{L_o\Delta T}$

Step 1: Rearrange for ΔL

$$\Delta L=\alpha\times L_o\times\Delta T$$

Step 2: Solve for ΔL_B (change in brass length)

$$\Delta L_I=(1.2\times 10^{-5})\times 10\times 750$$

$$\Delta L_I=0.09cm$$

Step 4: Find the difference between the two lengths

$\Delta L_B = \alpha_B \times L_{B_o} \times \Delta T_B$ $\Delta L_B = (1.9 \times 10^{-5}) \times 10 \times 800$ $\Delta L_B = 0.152cm$ **Step 3: Solve for L_I (change in iron length)** $\Delta L_I = \alpha_I \times L_{I_o} \times \Delta T_I$	$\Delta L = \Delta L_B - \Delta L_I$ $\Delta L = 0.152 - 0.09$ $\Delta L = 0.062cm$

3.7.2 Change of state

Latent Heat - Refers to the amount of energy released or absorbed by a chemical substance during a change of state that occurs without changing its temperature (ex. phase change from ice to water or water to steam)

Specific Latent Heat of Fusion - The amount of heat energy absorbed when a unit mass of a substance changes from a solid state to a liquid state at a constant temperature

1. A block of aluminum, 500g at 20°C was heated in a furnace until just when it melted

(i) Find the total quantity of heat required

Given: Mass of block, m = 500g or 0.5 kg
Initial temperature, To = 20°C = 293K
Final temp, T = 660°C = 933K (*This is the melting point of aluminum*)
Latent heat of fusion of aluminum, L_{Al} = 3.2 x 10^5JKg
Specific heat capacity of aluminum, Cal = 920 K/JKg
Heat required to melt aluminum: $mc_{Al}\Delta T + mL_{Al}$ or $m(c_{Al}\Delta T + L_{Al})$

Step 1: Calculate ΔT $\Delta T = 933 - 293 = 640$ **Step 2: Solve for heat required** $m(c_{Al}\Delta T + L_{Al})$	$0.5((920 \times 640) + (3.2 \times 10^5))$ $heat = 454400J$

(ii) If in this process the furnace consumes 100 litres of gas of calorific value 16800J/litres. Find its efficiency.

Given: Volume of the gas, 100 litres
Calorific value of the gas = 16800J/litre
Energy Absorbed = 454400J
Energy Supplied: $Energy\ Supplied = Given\ Volume \times Calorific\ Value$
Efficiency Equation: $Efficiency = \frac{Energy\ Absorbed}{Energy\ Supplied} \times 100\%$

Step 1: Calculate energy supplied $Energy\ Supplied = 100 \times 16800$ $Energy\ Supplied = 1680000J$	**Step 2: Calculate efficiency** $Efficiency = \frac{454400}{1680000} \times 100 = 27.05\%$

3.8.0 Vapour and humidity

3.8.1 Vapour

Evaporation - Causes the vapourization of a liquid, but occurs only on the surface of a liquid
Condensation - The change in the phase of matter from gaseous to liquid droplets
Saturated Vapour - A vapour which is in equilibrium with its liquid or solid
Unsaturated Vapour - A vapour which has not reached the state of dynamic equilibrium with its own liquid or solid
Factors effecting evaporation - Humidity, temperature, barometric pressure, surface area
Triple Point of Water - The temperature where all three states of water (liquid, gas (vapour), solid (ice)) exist in equilibrium
When a person perspires on a hot day, evaporation occurs and helps to cool the body
Warm air can hold more water vapour than cold air
Behaviour of a molecule in a liquid undergoing evaporation and then condensation - The molecule gains enough energy to escape the surface of the liquid through (evaporation). After it has escaped it

eventually loses energy and slows down, falling back into the liquid or forming droplets of the liquid elsewhere (condensation)

Differentiate between evaporation and boiling -

Evaporation	Boiling
• Occurs only on the surface of the liquid • Takes place at all temperatures	• Occurs throughout the liquid • Boiling occurs at a specific temperature depending on the pressure

3.8.2 Humidity

Hygrometer - An instrument used to measure relative humidity

Dew Point - Temperature at which water vapour present in the air is sufficient enough to saturate it

How dew is formed - As the surface of something cools by radiating its heat, atmospheric moisture condenses at a greater rate than it evaporates, resulting in the formation of water droplets

Relative Humidity - The measure of the amount of water vapour in the atmosphere

3.9.0 Current and electricity

3.9.1 Electromotive force (emf) and potential difference (pd)

Voltmeter - An instrument used for measuring the electric potential difference between two points in an electric circuit

Electric Potential - A point in space where the electrical potential energy divided by the charge that is associated with an electric field. It is a scalar quantity measured in volts or joule/coulomb

Electromotive Force (e.m.f) - The force which tends to cause current to flow

Potential Difference (p.d) - Is the potential difference between two terminals of a cell when the cell delivers current to the external circuit. Potential difference is always smaller than the electromotive due to resistance of the cell

Volt - The SI unit of the electromotive (e.m.f) force and the electric potential difference

Types of electric circuits - Open circuits, closed circuits

Open Circuits - A circuit which lacks a complete path between the positive and negative terminals of its power source

Closed Circuits - A circuit which has a complete path between the positive and negative terminals of its power source

Galvanometer - An instrument used for detecting and measuring electric current

Shunt - A device which allows electric current to pass around a point in a circuit

Motor - A machine which converts electrical energy into mechanical energy

Dynamo - A generator that produces direct current with the use of a commutator

Commutator - A rotary electrical switch in certain types of motors or generators which periodically reverse the current direction between the rotor and external circuit

Generators - A device which converts mechanical energy into electrical energy

Accumulator - An apparatus used to store energy

Examples of accumulators - Rechargeable batteries, capacitors, hydraulic accumulators

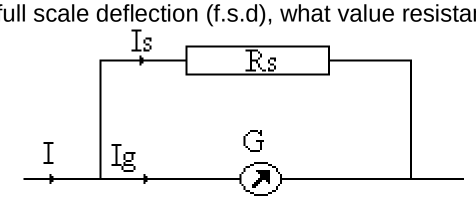
How you know it's necessary to recharge an accumulator - The stored charge has been depleted

1. A moving coil galvanometer of 30Ω resistance which carries a maximum current of 15mA can be converted into an ammeter

(i) How can the galvanometer be made to give ampere readings?

A galvanometer can be made to give ampere readings by connecting it in parallel to a low resistance called a shunt

(ii) If the device is to give 1.5A full scale deflection (f.s.d), what value resistance will be required?



Given: Current of device, I = 1.5A

Current in section g, I_g = 15mA or 0.015A

Current in section s, I_s = ?

Resistance of galvanometer, R_g = 30Ω

Resistance of resistor s, R_s = ?

Current in the circuit: $I = I_s + I_g$

$I_s R_s = I_g R_g$

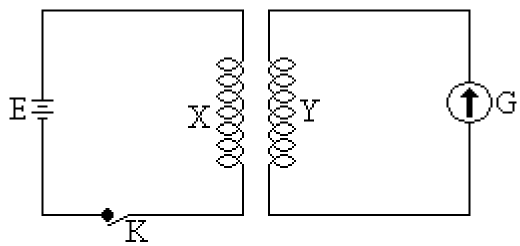
First we need to calculate the current in section S (I_s)

Step 1: Rearrange for I_s	Step 2: Solve for I_s
$I_s = I - I_g$	$I_s = 1.5 - 0.015 = 1.485A$

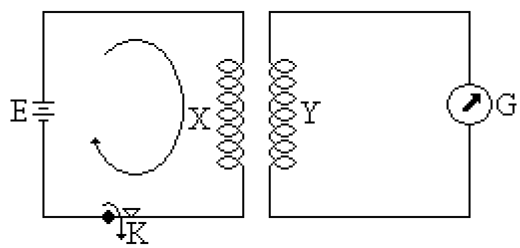
Now we can solve for R_s

Step 1: Rearrange for R_s	Step 2: Solve for R_s
$R_s = \frac{I_g R_g}{I_s}$	$R_s = \frac{0.015 \times 30}{1.485} = 0.303\Omega$

2. The figure below shows two coils X and Y. X is connected to a battery and Y is connected to a center zero galvanometer G.



(i) State and explain the deflection of the galvanometer needle when the switch K is closed for a few seconds and then opened.



If switch K is closed the galvanometer will deflect and then return to zero. When switch K is opened the galvanometer will deflect in the opposite direction and then return to zero. Deflection happens when K is opened and closed because this is when the flux changes in X and Y since the induced e.m.f depends on the rate of change of flux

(ii) Why must the galvanometer be a center zero type?
This is so that it can read deflections on either side

(iii) What would be done in X to increase the current induced in Y?
To increase the induced current in Y you need to increase the number of turns of X

<u>3.9.2 Resistance to electric current</u>

Ammeter - A measuring instrument which measures the electric current in a circuit
Resistor - A two terminal electronic component that produces a voltage across its terminals that is proportional to the electric current in accordance with Ohm's law (V = IR)
Thermistor - A type of resistor whose resistance varies significantly with temperature
Rheostat - A two terminal variable resistor used to vary resistance in a circuit
Resistivity - Is a measure of how strongly a material opposes the flow of an electric current
Ohm's Law - Current flowing through a conductor is directly proportional to the potential difference (p.d) across the conductor provided that the physical state of the conductor remains unchanged
Limitations of Ohm's Law - Does not apply to some electrolytes (Ex dilute H_2SO_4), does not apply to conduction in gases, does not apply to semiconductors (diodes and transistors)
Ohm's law is not applicable when <u>physical conditions of the wire are altered</u>
Factors affecting resistance of a wire - Length, resistivity, cross sectional area

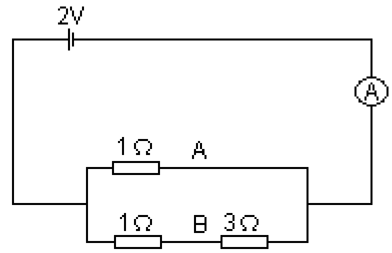
Length of wire (resistance increases with increasing length $(R \propto l)$

Resistivity/nature of the wire (resistance increases as resistivity increases $(R = \frac{\rho R}{A})$

Cross section area of the wire (resistance decreases with increasing cross section area of a wire $(R \propto \frac{1}{A})$

Resistance of a wire: $R = \frac{\rho l}{A}$

1. In the circuit shown in figure 1, the battery and ammeter have negligible internal resistance. What will be the ammeter reading?



Since part A and B are in parallel, you will add their inverse. In part B there are two resistors in series, so their resistances will be added

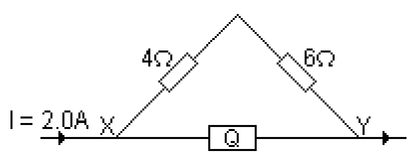
Part A: 1 Ω

Part B: 1 Ω + 3 Ω = 4Ω

$$Ammeter\ Reading = Part\ A + PartB$$

$$Ammeter\ Reading = 2\left(\frac{1}{1} + \frac{1}{4}\right) = 2.5A$$

2. In the circuit shown below, the total resistance between X and Y is 2.0 Ω. Calculate the unknown resistance Q



Given: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

R_{XY} = 2Ω

Q = ?

Note the denominator is 10 because the 6Ω and 4Ω resistors are in series so they are added 6 + 4 = 10

Step 1: Insert values into the equation for parallel resistors

$$\frac{1}{R_{XY}} = \frac{1}{10} + \frac{1}{Q}$$

$$\frac{1}{2} = \frac{1}{10} + \frac{1}{Q}$$

Step 2: Subtract the fractions

$$\frac{1}{Q} = \frac{1}{2} - \frac{1}{10}$$

$$\frac{1}{Q} = \frac{5}{10} - \frac{1}{10}$$

Step 3: Cross multiply

$$\frac{1}{Q} = \frac{4}{10}$$

$$4Q = 10$$

Q = **2.5 Ω**

(2b) A 2.0m long resistance wire of cross section 0.5mm^2 has a resistance of 2.2Ω. Find the:

(i) Resistivity of the material

Given: l = 2m
A = 0.5mm^2 or 5x10^{-7}m^2
R = 2.2 Ω
ρ = ?

Step 1: Rearrange for ρ	Step 2: Solve for ρ
$R = \frac{\rho l}{A}$ $\rho = \frac{RA}{l}$	$\rho = \frac{2.2 \times (5 \times 10^{-7})}{2}$ $\rho = 5.5 \times 10^{-7}$ Ωm

(ii) Length of the wire that would give a total resistance of 1.0 Ω when placed in parallel
Given: R_1 = 2.2 Ω
R_T = 1 Ω
R_X = ?

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_X}$$

First we need to find the resistance of the wire, then we can find the length

Step 1: Use the equation for parallel resistors	Step 3: Cross multiply
$\frac{1}{1} = \frac{1}{2.2} + \frac{1}{R_X}$ **Step 2: Subtract the fractions** $\frac{1}{R_X} = \frac{2.2}{2.2} - \frac{1}{2.2}$	$\frac{1}{R_X} = \frac{1.2}{2.2}$ 1.2R_X = 2.2 R_X = **1.833 Ω**

Now we need to solve for the length l

Given: R = 1.833Ω
ρ = 5.5x10^{-7}Ωm
A = 5x10^{-7}m^2
l = ?

$$R = \frac{\rho l}{A}$$

Step 1: Rearrange the equation for l	Step 2: Solve for l
$l = \frac{RA}{\rho}$	$l = \frac{1.833 \times (5 \times 10^{-7})}{5.5 \times 10^{-7}}$ l = **1.66m**

3. A 5Ω resistor and a 1Ω resistor are connected in parallel to a cell of e.m.f 6V and have an internal resistance of 0.5Ω. Calculate the current flowing around the circuit.

Given: E = 6V
R = ?
r = 0.5Ω
I = ?
Energy in a circuit: $E = I(R + r)$

First we must solve for R

Step 1: Use the equation for parallel resistors	
	$\frac{1}{R} = \frac{6}{5}$

	Step 2: Solve for R
$\frac{1}{R}=\frac{1}{5}+\frac{1}{1}$ $\frac{1}{R}=\frac{1}{5}+\frac{5}{5}$	$R=\frac{6}{5}$

Now we can solve for I

Step 1: Rearrange the equation for I	**Step 2: Solve for I**
$I=\frac{E}{R+r}$	$I=\frac{6}{\frac{5}{6}+0.5}=4.5A$

4. A wire of uniform cross sectional area has a length of 10m, a resistance of 2Ω and a resistivity of $2x10^{-7}$ Ωm. What is the cross sectional area in m^2?

Given: l = 10m
R = 2Ω
ρ = $2x10^{-7}$Ωm

Resistance of a wire: $R=\frac{\rho l}{A}$

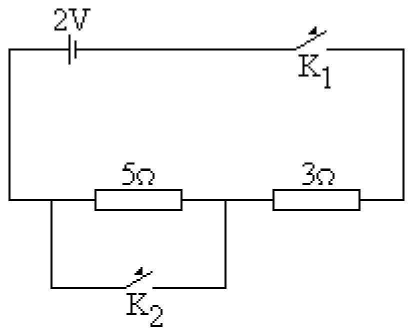
Step 1: Rearrange for A	**Step 2: Solve for A**
$A=\frac{\rho l}{R}$	$A=\frac{(2\times10^{-7})\times10}{2}$ $A=1\times10^{-6}m^2$

5. (a) If you are provided with resistors of 5Ω, 10Ω and 20Ω. What are the maximum and minimum resistances which can be obtained by connecting these resistors?

Note that maximum resistance occurs when all three resistors are connected in series and minimum resistance occurs when all three resistors are connected in parallel

Maximum	**Minimum**
$R=R_1+R_2+R_3$ $R=5+10+20$ $R=35\Omega$	$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ $\frac{1}{R}=\frac{1}{5}+\frac{1}{10}+\frac{1}{20}$ $\frac{1}{R}=\frac{4}{20}+\frac{2}{20}+\frac{1}{20}=\frac{7}{20}$ $R=\frac{20}{7}\Omega$

(b) Answer the following questions related to the circuit drawn below



Calculate the current passing through the circuit when:

(i) Switch K_1 is closed

If K_1 is closed, it will put both resistors in series, so their resistances are added (5 Ω + 3 Ω = 8Ω)

Given: V = 2V

R = 5 Ω + 3 Ω = 8 Ω

Current: $I = \frac{V}{R}$

$$I = \frac{2}{5+3} = \frac{2}{8} = 0.25A$$

(ii) Switches K_1 and K_2 are both closed

When both K_1 and K_2 are closed, the 5 Ω resistor is short circuited and will not affect the current

$$I = \frac{2}{3} = 0.67A$$

(iii) Switch K_1 is open and K_2 is closed

This will create an open circuit, therefore no current will flow (there is no path for the current to flow around the circuit)

3.9.3 Effects of an electric current

(Not found in exams)

3.9.4 Electric installation

Circuit Breaker - An automatically operated electrical switch designed to protect and electrical circuit from damage caused by overload or short circuits

Earthing (E) - A wire that is grounded to the earth

Live (L) - A wire that has a current running through it. They can kill you if you touch them

Neutral (N) -

Fuse - A protective device used to control electric current flowing in a circuit by using an alloy with a very low melting point. It breaks the current when the current is too high

1. Select the best fuse for the following:

(i) Refrigerator rated 250V, 400W Given: P = 400W V = 250V I = ? Power Equation: $P = IV$ or $I = \frac{P}{V}$ $I = \frac{400}{250} = 1.6A$, therefore a **2A fuse is best**	(ii) Electric cooker rated 240V, 7.2kW Given: P = 7.2kW or 7200W V = 240V $I = \frac{7200}{240} = 30A$, therefore a **30A fuse is best**	(iii) Electric iron rated 240V, 2kW Given: P = 2kW or 2000W V = 240V $I = \frac{2000}{240} = 8.3A$, therefore a **10A fuse is best**

3.9.5 Cells

Simple Cell - Any kind of battery in which the electrochemical reaction is not reversible (Ex. disposable battery)

Defects of a simple cell - Polarization, local action

Polarization - The process of formation of hydrogen gas around the positive plate of an electric cell. Minimized by using an oxidizing agent called a depolarizer (ex. K_2CrO_4)

Local Action - When a cell is used up when no external current is flowing as a result of impurities in the zinc plate. It is minimized by amalgamating zinc plate with mercury

How electromotive force (e.m.f) differs from the potential difference (p.d) of a cell -

Electromotive Force (e.m.f) - Is the potential difference between two terminals of a cell when the cell does not deliver current to an external circuit. The total work done in joules per coulomb of electricity in a circuit where the cell is connected. Measured in volts (V)

Factors determining the size of an induced e.m.f - Number of turns in the coil, strength of the magnet (magnetic field), rate of change of flux (speed of rotation or movement)

Potential Difference (p.d) - Is the potential difference between two terminals of a cell when the cell delivers current to the external circuit. Potential difference is always smaller than the electromotive due to resistance of the cell

Form 4

4.1.0 Waves

4.1.1 Introduction to waves

Frequency - The measurement of a waves cycles per second. Its SI unit is hertz (Hz)
Wavelength - The measurement of the rate at which the phase of a wave moves through space
Velocity (Phase) of a Wave - The fraction of a wave cycle which has happened over a given period of time
Period of a Wave - The duration of one cycle of a wave
Types of Waves - Stationary, longitudinal, mechanical, transverse

Stationary (Standing) Wave - A wave that remains in a constant position due to interference between two waves (ex resonance)

Longitudinal Waves - Waves that have the same direction of vibration along their direction of travel (the vibration of the medium is in the same or opposite direction as the motion of the wave)

Mechanical Waves - Waves which travel through materials (ex vibrating string, sound, seismic waves)

Transverse Waves -

Frequency of a wave: $f = \frac{1}{T}$

Velocity of a wave: $v = f\lambda$

4.1.2 Behaviour of waves

Interference - The superposition of two or more waves resulting in a new wave pattern (when two or more waves collide they create a new pattern, called an interference pattern)

Diffraction - Is the apparent bending of waves around small obstacles and the spreading out of waves past small openings. Diffraction occurs with all types of waves

4.1.3 Propagation of waves

1. A certain wave has a period of 0.2 sec and a wavelength of 60cm. What is the velocity of the wave in cm/s?

Given: Period of the wave, T = 0.2s
Wavelength, λ = 60cm
Frequency, f = ?
Velocity, v = ?

Frequency of a wave: $f = \frac{1}{T}$

Velocity of a wave: $v = f\lambda$

Step 1: Solve for frequency (f)	Step 2: Solve for velocity (v)
$f = \frac{1}{T}$	$v = f\lambda$ $v = 5 \times 60 = 300cm/s$

$f = \frac{1}{0.2} = 5Hz$	

4.1.4 Sound waves

Audibility Range - The range of sound waves which can be heard by an organism
Beats - Volume fluctuations due to the interference between sounds of different frequencies
Reverberation - The persistence of sound in a particular space after the original sound is removed, it is caused when a large number of echoes build up and then slowly decay as the sound is absorbed by the walls and air
Echo - A reflection of sound
A telephone earpiece converts electric currents into sound waves

4.1.5 Musical sound

Pitch - The perceived frequency of a sound
Loudness - The quality of a sound that is correlated to amplitude (the physical strength of a wave), which is heard by an organism and is measured in terms of a scale from quiet to loud
Node - A point where the amplitude of a standing wave is minimum
Anti-node - A point where the amplitude of a standing wave is maximum
Fundamental (Frequency) Note - The lowest frequency or note in a harmonic series
Harmonic Series - A series of notes which are formed on a string that travel in both directions along the string, reinforcing and canceling each other to form standing waves creating audible sound waves
Overtones - A frequency higher than the fundamental frequency of a sound
Resonance - The tendency of a system to oscillate with larger amplitude at some frequencies than at others
Oscillation - The repetitive variation over time about a central point of equilibrium (ex pendulum, AC power)
Amplitude - The magnitude of change in the oscillating variable with each oscillation within an oscillating system

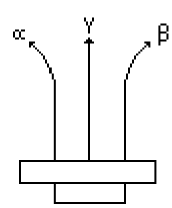
4.1.6 Electromagnetic spectrum

Electromagnetic Spectrum - The range of all possible frequencies of electromagnetic radiation
Types of Radiation - Ultraviolet, x-rays, gamma rays, infrared rays, visible light, beta particles, alpha particles

- **UV (Ultraviolet) Rays -** A form of electromagnetic radiation which is shorter than visible light, but longer than X-rays
- **X-rays -** A form of electromagnetic radiation which is shorter in wavelength than UV rays and longer than gamma rays
- **Gamma Rays -** A type of electromagnetic radiation of very high frequency (short wavelength) which are produced by subatomic particle interactions like radioactive decay. Can be used to kill cancer cells
- **Infrared Rays -** A form of electromagnetic radiation which is longer than visible light
- **Visible Light -** The portion of the electromagnetic spectrum that is visible to the human eye
- **Beta particles -** High energy, high speed electrons or positrons emitted by certain types of radioactive nuclei
- **Alpha Particles -** Consist of two protons and two neutrons bound together into a particle identical to a helium nucleus which is produced in the process of radioactive decay

Uses of electromagnetic radiation -

1. A mixed beam of α-particles, β-particles, and γ-rays enter a magnetic field at right angles to the direction of the beam. Draw the diagram which best represents the paths taken by the particles.



4.1.7 Applications of electromagnetic waves in daily life

4.2.0 Electromagnetism

4.2.1 Magnetic fields due to a current-carrying conductor

How an electric current creates a magnetic field -
Draw magnetic line patterns around a current

4.2.2 Electromagnetic induction

Electromagnetic Induction - A process where an e.m.f is induced in a coil which is interacting with a magnetic field whenever the flux through the coil changes

Applications of electromagnets -

Laws of electromagnetic induction -

Faradays Law - Whenever there is a change in the magnetic flux linked with a circuit an electromotive force (e.m.f) is induced, the strength of which is proportional to the rate of change of the flux linked with the circuit

Lenz's Law - The direction of induced current is always such that it opposes the change producing it

Magnetic Flux - A measure of the strength of a magnetic field on one side of a magnet. Its SI unit is V/sec

Inductor - A coil of low resistance wire used to store magnetic flux and control an alternating current (AC)

Eddy Current - Induced current loops circulating within a conductor

Advantages of eddy currents - Useful in heating metals, electrical damping, crack detection, measurement of thickness of the material or coating, measurement of conductivity

How eddy currents are produced - Produced when flux through a piece of metal changes, it induces an e.m.f. This induced e.m.f causes currents to flow around the metal piece in closed loops. The current is significant because the resistance of the path is very low

How to minimize eddy currents - Using laminated cores, using magnetic materials with high resistivity

Solenoid - A long thin loop of wire wrapped around a metallic core which produces a magnetic field when an electric current is passed through it. They are used as electromagnets

Self Induction - The induction of a magnetic field by its own current

Mutual Induction - The induction of a magnetic field by current in another circuit

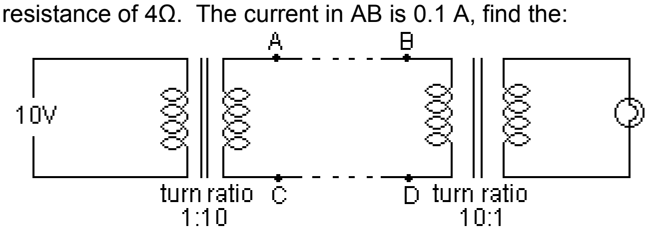
Factors affecting the magnitude of an induced e.m.f in a moving coil - Strength of the magnetic field, speed of rotation of the coil

Transformer - A device which transfers electrical energy from one circuit to anther through the transformer's coils

Reason why high voltage is used for commercial transmission of electrical energy - It minimizes energy losses because high voltage provides lower current. From the equation Power = I^2R, so the lower the current, the lower the power losses

Transformer principle: $\frac{N_S}{N_P} = \frac{E_S}{E_P}$

1. The figure shows a model of an electrical transmission system. AB and CD each represent a long length of cable each having a resistance of 4Ω. The current in AB is 0.1 A, find the:



(i) Power lost by AB and CD

Note that since AB and CD have the same resistance, so they will have the same current

Given: I = 0.1
R = 4Ω
P = ?

Power lost due to resistance: $P = I^2R$

Step 1: Solve for P	**Step 2: Calculate total power lost.** *Note that you need to multiply the power lost by two because we are considering AB and CD, each one lost 0.04W*
$P = I^2R$ $P = (0.1)^2 \times 4$ $P = 0.04W$	$Total = 0.04 \times 2 = 0.08W$

(ii) P.d across BD

Given: $N_S = 10$
$N_P = 1$
$E_P = 10$
$E_S = ?$

Transformer principle: $\frac{N_S}{N_P} = \frac{E_S}{E_P}$

Step 1: Rearrange for E_S $E_S = \frac{N_S}{N_P} \times E_P$ Step 2: Solve for E_S	$E_S = \frac{10}{1} \times 10 = 100V$ **Step 3: Solve for E_{CD}** (????)Explain this question better, why is $E_S = E_{AC}$, what do the variables mean? NECTA 2007 10bii

(iii) Current through the bulb
Given: $N_P = 10$
$N_S = 1$
$I_P = 0.1$
$I_S = ?$

Transformer principle: $\frac{N_S}{N_P} = \frac{I_P}{I_S}$

Step 1: Rearrange for I_S	**Step 2: Solve for I_S**
$I_S = \frac{N_P}{N_S} \times I_P$	$I_S = \frac{10}{1} \times 0.1 = 1.0A$

4.3.0 Radioactivity

4.3.1 The nucleus of an atom

Protons - Positively charged particles of an atom which have a mass equal to that of a hydrogen atom
Neutrons - Particles of an atom with an equal mass to protons that carry no charge
Electron - A particle which carries a negative charge, it is smaller than protons and neutrons
Radiation - A process in which energetic particles or waves travel through a medium or space

4.3.2 Natural radioactivity

Naturally occurring forms of radiation - Alpha particles (α-particles), beta particles (β-particles), gamma rays (γ-rays)
α-particles - Particles with low penetrating power which can be stopped by very thin aluminum foil, normal paper or by the human skin. They also have a limited range in the air because the ionize air
β-particles - Particles with high penetration power which can penetrate many metals (or only a few cm of lead), can penetrate human tissue. They can travel long distances in air because they do not ionize air
γ-rays - Rays with very high penetrating power (higher than β-particles) which can penetrate many metals (or only a few cm of lead) and can penetrate human tissue. They can travel very far in the air because they do not ionize air
Half Life - The time required for half of the present number of atoms to decay
Ionizing Radiation - Consists of subatomic particles or electromagnetic waves which are energetic enough to detach electrons from atoms or molecules, thus ionizing them
Geiger-Mullar Counter - A particle detector that measures ionizing radiation

Differentiate between beta (β) particles and gamma (γ) rays -

β-particles	γ-rays
• Deflected by electric and magnetic fields • Penetrates a few centimeters of an aluminum sheet • Is an electron • It has mass	• Not deflected by electric or magnetic fields • Penetrates a few centimeters of lead • Is electromagnetic radiation • Has no mass

1. A radioactive element has an initial count rate of 1200 counts per minute measured by a scale and this falls to 150 counts per minute in 15 hours.

(i) Determine the half life of the element

Given: C_o = 1200 counts per minute
C = 150 counts per minute
t = 15 hours
n = number of half lives = ?
$t_{1/2}$ = ?

Calculating number of half lives: $C = \frac{C_o}{2^n}$

Calculating length of half life: $t_{1/2} = \frac{t}{n}$

Step 1: Rearrange for 2^n	**Step 3: Solve for half life time**
$2^n = \frac{C_o}{C}$	$t_{1/2} = \frac{t}{n}$
Step 2: Solve for n	
$2^n = \frac{1200}{150}$	$t_{1/2} = \frac{15}{3} = 5h$
$2^n = 8$	*The half life of the element is **5 hours***
n = 3	

(ii) If the initial number of atoms in another sample of this element is $3.0\text{x}10^{20}$, how many atoms will have decayed in 25 hours?

Given: Initial number of atoms, $N_o = 3.0\text{x}10^{20}$ atoms
Time, t = 25 hours
Length of half life, $t_{1/2}$ = 5 hours
Number of half lives, n = ?
Number of atoms decayed, N = ?

Calculating length of half life: $t_{1/2} = \frac{t}{n}$

Calculating number of half lives: $N = \frac{N_o}{2^n}$

Step 1: Calculate n	**Step 2: Calculate N (number of atoms decayed)**
$t_{1/2} = \frac{t}{n}$	$N = \frac{N_o}{2^n}$
$5 = \frac{25}{n}$	$N = \frac{3.0 \times 10^{20}}{2^5}$
n = 5	N = $9.375 \text{ x } 10^{18}$ atoms

2. Thorium disintegrates in the following manner

$${}_{90}Th^{232} \longrightarrow {}_{88}Ra^{228} \longrightarrow {}_{89}Ac^{228} \longrightarrow {}_{90}Th^{228} \longrightarrow {}_{88}Ra^{224}$$

State the particles being emitted at each part of the disintegration

Step 1 - Emits an α-particle

$${}_{90}Th^{232} \longrightarrow {}_{88}Ra^{228} + {}_{2}\alpha^{4}$$

Step 2 - Emits a β-particle

$${}_{88}Ra^{228} \longrightarrow {}_{89}Ac^{228} + {}_{-1}\beta^{0}$$

Step 3 - Emits a β-particle

$${}_{89}Ac^{228} \longrightarrow {}_{90}Th^{228} + {}_{-1}\beta^{0}$$

Step 4 - Emits an α-particle

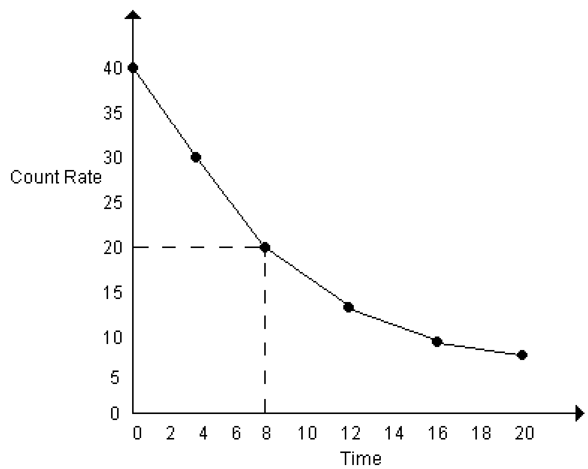
$${}_{90}Th^{228} \longrightarrow {}_{88}Ra^{224} + {}_{2}\alpha^{4}$$

Final Equation

$${}_{90}Th^{232} \xrightarrow{\alpha} {}_{88}Ra^{228} \xrightarrow{\beta} {}_{89}Ac^{228} \xrightarrow{\beta} {}_{90}Th^{228} \xrightarrow{\alpha} {}_{88}Ra^{224}$$

(ii) Draw the graph of count rate against time for the following data, then determine the half life of thorium

Time (mins)	0	4	8	12	16	20
Count Rate	40	30	20	14	10	7



By looking at the graph we can see that the half life of thorium is 8 minutes. Since the original count was 40, we look at 20 to see at what time it occurs. Since it occurs at 8 minutes, the half life of thorium is 8 minutes. This is shown by the dotted lines

4.3.3 Artificial radioactivity

Differentiate between natural and artificial radioactivity - Natural radioactivity happens due to the properties of the substance causing it to decay over time, whereas artificial radioactivity is caused by the actions of humans adding neutrons to the atoms causing them to become unstable and decay

Applications of artificial radioactivity - Particle accelerators, nuclear power

4.3.4 Radiation hazards and safety

Precautions when handling radioactive material - Material should be stored in lead casing, package should be labeled appropriately, package should be handled carefully

4.3.5 Nuclear fission and fusion

Differentiate between nuclear fission and nuclear fusion -

- **Nuclear Fission -** A process whereby a large atomic nucleus is split into two smaller particles, releasing energy and radiation
- **Nuclear Fusion -** The process in which two or more atomic nuclei join together to form a single heavier nucleus

Applications of nuclear fission - Nuclear power, research, nuclear bombs

Applications of nuclear fusion - Hydrogen bombs

4.4.0 Thermionic emission

4.4.1 Cathode rays

Thermionic Emission - A process in which electrons gain sufficient enough energy to overcome the work function of the metal and are able to escape from the surface of the metal

Cathode Ray - A stream of electrons in vacuum tubes (evacuated glass tubes)

- **Properties of cathode rays -** Produce fluorescence, are deflected by electric and magnetic fields, travel in straight lines, carry negative charge, posses kinetic energy

Cathode Ray Oscilloscope (CRO) -

- **Uses of CRO -** Measuring frequencies, measuring voltages, measuring phase differences, measuring small time intervals
- **Main parts of a CRO -** Electron gun, deflection system, fluorescent screen
- **How a stream of electrons is produced in a CRO -** They are released from the cathode by thermionic emission, then they are accelerated by the anode to a high velocity forming the stream of electrons
- **Ensuring electrons produced do not accumulate at the source -** The device uses anodes to accelerate the protons
- **Ensuring electrons reach their range undeviated -** A focusing anode is used
- **Ensuring electrons travel without meeting other particles on their way to the target -** The devices are evacuated so that the electrons do not collide with other particles

Cathode Ray Tube (CRT) -

- **Cathode Rays -** Streams of electrons inside an evacuated CRT
- **Uses of a cathode ray tube -** Television
- **Why cathode ray tubes are evacuated -** So that electrons can travel without colliding with other molecules
- **Effects when gas is maintained in a CRT -** It will behave like an open circuit and when the potential difference (p.d) is strong enough, it will cause an electric spark. Also, an image will not be formed because cathode rays will not be present
- **Role of high voltage -** Provides high tension between electrodes which is used for acceleration of electrons
- **Role of low voltage -** To heat up the cathode
- **Role of tungsten target -** Used to absorb highly energetic electrons and to emit X-rays by converting kinetic energy of the electrons into electromagnetic waves

4.4.2 X-rays

X-rays -

- **Properties of X-rays -** Travel in straight lines at the speed of light, cannot be deflected by electric or magnetic fields, can produce fluorescence, affect photographic film, penetrate matter (dependent on density of the matter), ionize gases, are diffracted by crystals
- **Effects of X-rays on humans -** Destroys body cells, causes mutation of DNA, can cause cancer, can destroy fertility
- **How to produce X-rays -** An accelerated electron beam is focused onto a target with a high melting point. The fast moving electrons collide with the targets atoms and excite them. This causes the electrons of the atoms to go to higher energy levels and jump back to lower energy levels, emitting X-rays (photons)

Types of X-Rays - Hard, soft

- **Hard X-Ray -** An X-ray which can penetrate solid objects
  - **How hard X-rays are produced -** Produced when a very high voltage is applied between electrodes which accelerates electrons which release X-rays when they hit the tungsten target
- **Soft X-Ray -** Ax X-ray which cannot penetrate solid objects

Differentiate between X-rays and gamma (γ) rays -

X-rays	Gamma Rays
• Caused by energy transitions in electrons • Material used to produce X-rays does not decay • Wavelength of X-rays is determined by the nature of the target material and voltage (varying strength) • X-rays are emitted by stable atoms of heavy nuclei when hit by fast moving electrons	• Caused by nuclear reactions in the nucleus • Material sued to produce gamma rays decays • Gamma rays depend upon the nucleus of the material for their wavelength • Gamma rays are produced only when newly formed nuclei are energetically unstable (the stability is gained by emitting gamma rays)

Differentiate between X-rays and white light -

X-rays	White light
• Cannot be detected by the human eye • Range of frequencies is variable • Highly penetrative	• Can be detected by the human eye • Has a fixed range of frequencies • Can only penetrate transparent and translucent matter

4.5.0 Electronics

4.5.1 Semiconductors

Semiconductor - A material with electric conductivity due to electron flow which is an intermediate in magnitude between a conductor and an insulator

Semiconductors commonly used in electronics - Silicon, germanium

Doping (of Semiconductors) - Adding small amounts of impurities to semiconductors to improve their conductivity

P-Type Semiconductor - A type of semiconductor which is obtained through doping which increase the number of positive charge carriers

N-Type Semiconductor - A type of semiconductor where atoms are capable of providing extra conduction electrons to the host material which creates an excess of negative electron charge carriers

P-Type Doping - Creates an abundance of electron holes which allows atoms to accept electrons from a neighbouring atoms covalent bond

Extrinsic Semiconductor - A semiconductor which has been doped giving it different electrical properties than an intrinsic (pure) semiconductor

Intrinsic (Pure) Semiconductor - A semiconductor which has not been doped and therefore has the natural electrical properties of the semiconductor

Electron Hole - Is the concept of the lack of an electron at a position where one could exist in an atom

Differentiate between conductors and semiconductors -

Conductors	Semiconductors
• More sensitive to electric and magnetic fields due to free electrons being readily available • The conduction band overlaps the valence band (there is no forbidden gap)	• Less sensitive to electric and magnetic fields due to a lack of free electrons • Conduction and valence bands are separated by a thin forbidden gap • Electrons can jump over the forbidden gap when they gain sufficient energy

4.5.2 Diodes

Diode - A two terminal electronic component that conducts electric current in only one direction

Junction Diode -

How a junction diode works - Relies on the fact that current flows easily from P-type to N-type diodes. When P-type is connected to the anode it attracts electrons from the N-type, while the N-type attracts holes from P-type which closes the depletion layer. In the reverse direction the depletion layer will be widened

Rectification - The process of converting an alternating current into a direct current

Role a capacitor plays when used in - AC circuits, DC circuits

AC Circuits - Used in amplifiers for separating AC from DC, in radios for tuning, and in rectification for smoothening

DC Circuits - Charge storage when charging or discharging. When discharging a capacitor can act as an e.m.f source

4.5.3 Transistors

Transistor - A semiconductor device which is used for the amplification of current and voltage

N-type Transistor -

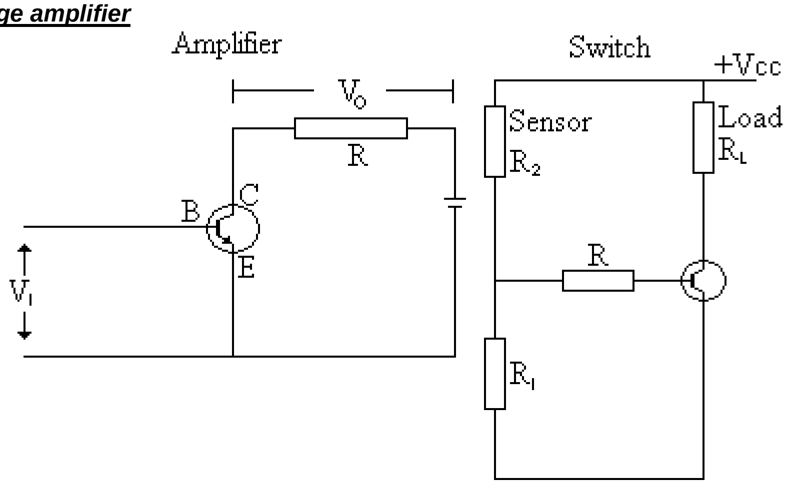
P-type Transistor -

Principle of a transistor - It is made of two pieces of either N-type or P-type material with the other type in between them. The outer pieces are used as a collector and emitter while the middle piece is used as the base and is thinner than the outer pieces. During operation a small current is passed from the base to the emitter or its reverse. This small current starts a larger current from the collector to the emitter through the base or its reverse

Differentiate between NPN and PNP transistors -

PNP transistors	NPN transistors
• Consist of a N-type base between two P-type semiconductors • Slower than NPN because holes are slower than electrons • Holes are the majority charge carriers • Collector and base are negative with respect to the emitter	• Consist of a P-type base between two N-type semiconductors • Are faster than PNP so they are used more often • Electrons are the majority charge carriers • The collector is positive with respect to both the emitter and to the base

4.5.4 Single stage amplifier



4.6.0 Elementary astronomy

4.6.1 Introduction to astronomy

Astronomy - The scientific study of the objects in the universe like stars, galaxies, planets and comets
Asteroids - A collection of particles of various sizes which revolve around the sun in a way similar to planets
Comets - An asteroid which glows brightly in space
Stars - Heavenly bodies which produce their own energy (light and heat)
Planets - Heavenly bodies that cannot produce their own energy and revolve around stars
Meteor - Asteroids that enter into the Earth's atmosphere and burn up completely before reaching the surface of earth
Meteoroid - Solid object moving in interplanetary space and is smaller than an asteroid
Lunar Eclipse - Occurs when the moon passes behind the earth such that the earth blocks the sun's rays from striking the moon
Galaxy - A massive gravitationally bound system of stars and gases. Our galaxy is the Milky Way

4.6.2 Solar system

Differentiate between a star and a planet - A star is capable of emits its own energy through the fusion of hydrogen atoms, a planet creates energy internally through geothermic actions
Solar System - A system consisting of the sun and all of the astronomical objects bound to it by gravity
Gravity - The force of attraction that causes bodies to fall towards heavier bodies like planets or stars. This is the force that causes planets to revolve around the sun
Heliocentric Theory - The sun is at the centre of the solar system and all other bodies including the Earth revolve around it in circular orbits while rotating about their axes. This is a true theory
Geocentric Theory - Claims that the Earth is at the center of the solar system and the sun and other planets revolve around Earth. This is not a true theory
Basic trends of the planets -
- **Average temperature of the planets -** Average temperature decreases as distance from the sun increases because they are further away from the heat source (sun)
- **Average densities of the planets -** Densities generally decrease from Mercury to Saturn and then increase from Saturn to Neptune. Earth has the highest density because its core is made of iron and nickel, while Saturn has the lowest density because it is made of gases
- **Length of revolutions of the planets -** Period of revolutions increases as distance from the sun increases

Why an astronaut…
- **Needs a spacesuit to prevent his blood from boiling -** The body temperature of the astronaut is enough to boil his blood because there is nearly zero atmospheric pressure
- **Floats without falling -** There is almost no gravitational force so he does not fall towards anything
- **Uses jets of gas to move instead of swimming like in water -** He cannot swim because there is no matter to push against, in order to move forward he needs to exert a force on surrounding matter

<u>Mercury</u> has no atmosphere and is the closest planet to the sun
<u>Neptune</u> is the farthest planet from the sun *(Note that Pluto is no longer considered a planet)*
<u>Mars</u> is the closest planet to the Earth
<u>Saturn</u> is surrounded by rings
<u>Jupiter</u> is the largest planet in the solar system

Venus is the brightest planet in the solar system

4.6.3 Constellations

Constellation - A certain area in the celestial sphere that can be used for navigation based on the perceived pattern formed by prominent stars in the night sky

4.6.4 The earth and the moon

Tides - The rise and fall of sea levels caused by the effects of gravitational forces by the moon, sun and the rotation of the earth

Mass and weight on the Earth and Moon - Mass never changes since it is not affected by gravity (it will be the same on the Moon and on Earth. Weight will change because weight is affected by gravity (it will be heavier on Earth and lighter on the Moon)

1. The distances of Jupiter from the sun 7.8 x 10^8km and one year on Jupiter is equivalent to 12 years on earth. Calculate the:

(i) Distance of its path in one year

Given: Radius of the path, 7.8 x 10^8km

Circumference of a circle: $C = 2\pi r$

Note that the distance of its path is the circumference of a circle, since Jupiter has a circular orbit

Step 1: Calculate circumference

$$C = 2\pi r$$

$$C = 2 \times \pi \times (7.8 \times 10^8)$$

$$C = 4.903 \times 10^9\, km$$

(ii) Speed of the planet in km per hour

Given: Distance = 4.903 x 10^9km

Time = 12 years x 365 days x 24 hours = 105,120 hours

Speed: $Speed = \frac{Distance}{Time}$

Step 1: Calculate speed

$$Speed = \frac{Distance}{Time}$$

$$Speed = \frac{4.903 \times 10^9}{105{,}120} = 46{,}641\, km/hr$$

4.7.0 Geophysics

(Found in the Geography study guide)

How to write a comprehensive essay

1. An essay has three main parts
   A: Introduction
   B: Body
   C: Conclusion

2. A: Introduction

Components of an introduction - Defining the concept, giving short explanations (history, origins, forms, types, dates, years etc)

Important Points -

- Read your question carefully two or more times until you understand it completely
- Identify the key words which you will need to define
- Define key words carefully and then elaborate on them in the paragraph

Example -

1. Explain the importance of government in Tanzania.

Step 1: *First you need to identify the important words in the question and words which need to be defined*

Explain the importance of government in Tanzania

Step 2: *Now you need to define the words which need to be defined and think about the what the question is asking for*

Government → This is a word which must be defined
Importance → This is a word which indicates that the question is asking you to explain with examples

B: Body

Components of the main body - Points with supporting explanations or evidence with concrete and relevant examples (usually 5 points for O level NECTAs). Your explanations should be clear and precise to support your point

Important Points -

- This is an important part of the essay because it is where your ideas/points are elaborated with examples and clear explanations
- Arrange your points clearly and make sure you leave enough space after the margin
- Make sure you use coordinators to join your points together like by using the words however, also, not only that, but also, etc

Example of the main body - You will need to remember to indent the first sentence of every paragraph in the essay

C: Conclusion

Components of a conclusion - Your own opinions on the topic, a short summation of what you have explained in the main body

Important Points -

- Since it is a summary of the main body, you do not need more explanations
- This is the part where you can give your opinions, advice and views on the topic

- Do not write the same conclusion every time, since it will change depending on the nature of the question being asked
- Avoid the use of pronouns or poor word choices when starting your conclusion (ex. I conclude…, From the above…, Conclusion…). Instead you can start without using any leading words or use better words like ‘Therefore,…’ to tie your essay together