Section A: Mechanics

1. **Measurement and Units**
   - Physical quantities and their units
   - Use of SI units and standard prefixes
   - Scalar and vector quantities
2. **Motion**
   - Distance, displacement, speed, velocity, and acceleration
   - Graphs of motion
   - Equations of uniformly accelerated motion
   - Projectile motion
3. **Forces**
   - Types of forces
   - Newton's laws of motion
   - Frictional forces
   - Circular motion and centripetal force
4. **Energy and Work**
   - Work done by a force
   - Forms of energy and energy conversion
   - Principle of conservation of energy
   - Power and efficiency
5. **Momentum**
   - Linear momentum and impulse
   - Conservation of linear momentum
   - Collisions
6. **Statics**
   - Principle of moments
   - Conditions for equilibrium
   - Centre of gravity
7. **Hydrostatics**
   - Pressure in fluids
   - Archimedes' principle
   - Principle of flotation

SECTION A: MECHANICS

Mechanics is the branch of physics that deals with the motion of objects and the forces that cause or change that motion. It includes several key areas:

1. Measurement and Units

Subtopic	Explanation
Physical Quantities	These are properties that can be measured. They are either **scalar** (magnitude only) or **vector** (magnitude and direction).
SI Units	The International System of Units (SI) provides standard units for all physical quantities. See table below.
Prefixes	Used to express very large or small quantities conveniently.
Instruments for Measurement	Common instruments include meter rules, vernier calipers, micrometer screw gauges, and stopwatches.

Table 1: Common Physical Quantities and SI Units

Quantity	SI Unit	Symbol	Type
Length	metre	m	Scalar
Mass	kilogram	kg	Scalar
Time	second	s	Scalar
Temperature	kelvin	K	Scalar
Electric current	ampere	A	Scalar
Luminous intensity	candela	cd	Scalar
Amount of substance	mole	mol	Scalar
Displacement	metre	m	Vector
Velocity	m/s	m/s	Vector
Acceleration	m/s^2	m/s^2	Vector
Force	newton	N	Vector

Table 2: SI Prefixes

Prefix	Symbol	Factor	Power of 10
Giga	G	1,000,000,000	10^{9}
Mega	M	1,000,000	10^{6}
Kilo	k	1,000	10^{3}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	µ	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}

2. Motion

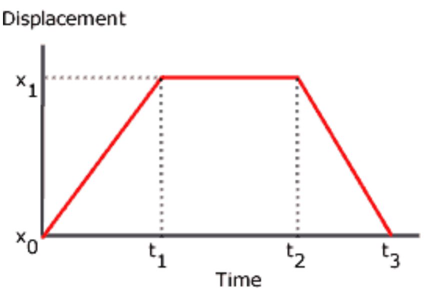
Subtopic	Explanation
Distance vs Displacement	Distance is total path length (scalar); displacement is the straight-line change in position (vector).
Speed vs Velocity	Speed is scalar (distance/time); velocity is vector (displacement/time).
Acceleration	Rate of change of velocity: $a = (v - u)/t$
Graphs of Motion	Position-time and velocity-time graphs help visualize motion.
Equations of Motion	Apply to uniform (constant) acceleration.
Free Fall	Vertical motion under gravity only (acceleration = 9.8 m/s²).
Projectile Motion	Object projected at an angle follows a parabolic path due to horizontal velocity and vertical acceleration.

Equations of Uniformly Accelerated Motion

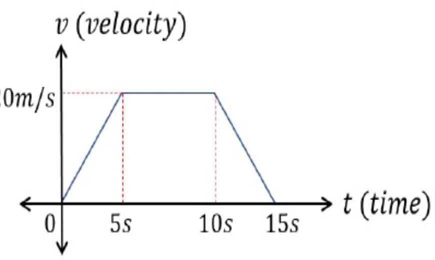
Equation	Meaning
$v = u + at$	Final velocity
$s = ut + \frac{1}{2}at^2$	Displacement
$v^2 = u^2 + 2as$	Relation between v, u, a, s
$s = ((u + v)/2) \times t$	Average velocity × time

Where:

- u = initial velocity
- v = final velocity
- a = acceleration
- s = displacement
- t = time



Gradient = Velocity



Gradient = Acceleration **Area under graph= Distance travelled**

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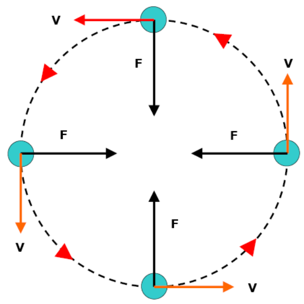
3. Forces

Subtopic	Explanation
Definition of Force	A push or pull acting on an object.
Types of Forces	Contact (friction, tension, normal) and non-contact (gravitational, magnetic).
Newton's Laws of Motion	Fundamental principles governing how forces affect motion.

Free-body Diagrams	Visual representations of all forces acting on an object.
Friction	Opposes motion between surfaces in contact.
Circular Motion	Motion in a circle due to a **centripetal force** acting toward the center.



Direction changing

⇩

Velocity changing

⇩

It has an acceleration

⇩

It has a resultant force [Force = Centripetal Force]

Newton's Three Laws of Motion

1. **Law of Inertia:** An object remains at rest or in uniform motion unless acted upon by an external force.
2. **F = ma:** Force equals mass times acceleration.
3. **Action–Reaction:** For every action, there's an equal and opposite reaction.

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4. Energy and Work

Subtopic	Explanation
Work	Done when a force moves an object through a distance: $W = F \times d$
Kinetic Energy	Energy due to motion: $KE = \frac{1}{2}mv^2$
Potential Energy	Energy due to position: $PE = mgh$
Conservation of Energy	Total energy in a closed system is constant.
Power	Rate of doing work: $P = W/t$
Efficiency	Ratio of useful energy output to input: $\eta = (\text{useful output/input}) \times 100\%$

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5. Momentum

Subtopic	Explanation
Momentum	p = mv (vector quantity).
Impulse	Force × time = change in momentum.
Conservation of Momentum	Total momentum before = total momentum after (in the absence of external forces).
Collisions	Elastic: kinetic energy conserved; Inelastic: kinetic energy not conserved, but momentum is.

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6. Statics

Subtopic	Explanation
Equilibrium	Net force and net moment on a body is zero, ie **upward forces = downward forces**
Moment (Torque)	Turning effect of a force: Moment = Force × Perpendicular Distance from pivot.
Principle of Moments	Sum of clockwise moments = sum of anticlockwise moments.
Centre of Gravity (CoG)	The point at which the whole weight of an object appears to act. Determined by suspension or symmetry. To increase stability you can : • Lower the centre of gravity • Wider the base

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7. Hydrostatics

Subtopic	Explanation
Pressure on solids	P = $\frac{force}{area}$ [Pascals/Pa]
Pressure in Fluids	P = ρgh (ρ = fluid density, g = gravity, h = depth).
Buoyant Force	Upthrust = weight of fluid displaced (Archimedes' Principle states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid). Upthrust = Weight of fluid it displaces

	$= M_f g$ $= P_f V_s g$
Flotation	A body floats if its weight = upthrust. If object is less dense than fluid, it floats. A) float: u = w B) sink: w > u C) rise: u > w

Section B: Thermal Physics and Kinetic Theory

1. **Thermal Expansion**
    - Expansion of solids, liquids, and gases
    - Applications and consequences of thermal expansion
2. **Temperature and Thermometers**
    - Temperature scales (Celsius and Kelvin)
    - Thermometric properties and types of thermometers
3. **Heat Transfer**
    - Conduction, convection, and radiation
    - Applications of heat transfer methods
4. **Quantity of Heat**
    - Specific heat capacity
    - Specific latent heat
    - Calculations involving heat energy
5. **Kinetic Theory of Matter**
    - States of matter and molecular structure
    - Brownian motion
    - Gas laws and absolute zero

🌡️ SECTION B: THERMAL PHYSICS AND KINETIC THEORY

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1. Thermal Expansion

Subtopic	Explanation
Expansion of Solids, Liquids, and Gases	When substances are heated, their particles move more vigorously, leading to an increase in volume. Gases expand most, followed by liquids, and then solids.
Linear, Area, and Volume Expansion	Solids expand in one, two, or three dimensions. Gases and liquids typically show volume expansion.
Applications and Consequences	Expansion is useful in devices like bimetallic strips and problematic in bridges and pipelines without expansion joints.

Key Points:

- Solids expand slightly and uniformly.
- Liquids expand more than solids.
- Gases expand significantly when heated at constant pressure.

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2. Temperature and Thermometers

Subtopic	Explanation
Temperature	A measure of the average kinetic energy of particles in a substance.
Scales of Temperature	Celsius (°C), Kelvin (K), Fahrenheit (°F). C and K are most used in physics.
Thermometric Properties	Physical properties that vary with temperature (e.g., length of a mercury column, resistance of a wire).
Types of Thermometers	Liquid-in-glass (mercury/alcohol), thermocouple, resistance thermometer, infrared thermometer.
Fixed points	**Upper fixed points-** The upper fixed point, or steam point, is the temperature of pure boiling water at normal atmospheric pressure. [100^0C] **Lower fixed points-** The lower fixed point, or ice point, is the temperature of pure melting ice at normal atmospheric pressure. [0^0C]

Table: Celsius vs Kelvin

Celsius (°C)	Kelvin (K)
0°C	273 K
100°C	373 K
-273°C	0 K

Conversion:
K = °C + 273

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3. Heat Transfer

Subtopic	Explanation
Conduction	Transfer of heat through solids from molecule to molecule without bulk movement.
Convection	Transfer of heat in fluids (liquids/gases) through movement of warmer regions.
Radiation	Transfer of heat as electromagnetic waves (infrared), no medium required.
Applications	Cooking, home insulation, cooling devices, engines, and solar panels.

Table: Comparison of Heat Transfer Methods

Property	Conduction	Convection	Radiation
Medium	Solids	Liquids & gases	Vacuum, gases, solids
Particle motion	Vibration	Bulk movement	None (EM waves)
Speed	Slow	Moderate	Fast
Examples	Metal rod heating	Water boiling	Sun heating Earth

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4. Quantity of Heat

Subtopic	Explanation
Heat Capacity (C)	Quantity of heat required to raise the temperature of a body by 1°C or 1 K. [**C = mc**]
Specific Heat Capacity (c)	Heat required to raise 1 kg of a substance by 1°C (unit: J/kg·K).
Latent Heat	Heat absorbed/released during a change of state with no temperature change.

Specific Latent Heat of Fusion and Vaporization	Fusion (solid to liquid), vaporization (liquid to gas).
Calculations	Use $Q = mc\Delta T$ and $Q = mL$ for heating/cooling and state changes respectively.

Key Formulas:

- Heat energy: $\mathbf{Q = mc\Delta\theta}$ **used during temperature changes**
- Latent heat: $\mathbf{Q = mL}$ **used during phase changes**

Where:

- Q = heat energy
- m = mass
- c = specific heat capacity
- $\Delta\theta$ = change in temperature
- L = specific latent heat

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5. Kinetic Theory of Matter

Subtopic	Explanation
States of Matter	Solid, liquid, and gas — each with different particle arrangements and energy levels.
Brownian Motion	Random movement of particles suspended in a fluid, evidence of molecular motion.
Assumptions of the Kinetic Theory	Gases consist of small particles in constant, random motion. Collisions are elastic. No forces between particles. Volume of particles is negligible compared to container.
Gas Laws	Relationships between pressure, volume, and temperature of a **fixed mass of gas.**

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6. Gas Laws

Subtopic	Explanation
Boyle's Law	At constant temperature, pressure × volume = constant: $\mathbf{P \propto 1/V}$ or $\mathbf{P_1 V_1 = P_2 V_2}$
Charles' Law	At constant pressure, volume ∝ temperature (K): $\mathbf{V \propto T}$ or $$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Pressure Law (Gay-Lussac)	At constant volume, pressure ∝ temperature (K): **P ∝ T** or $$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$
Combined Gas Law	**PV/T = constant** — combines all three laws. $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
Absolute Zero	The lowest possible temperature (0 K or -273°C), where particles have minimal kinetic energy. **ALL TEMPERATURES MUST BE IN KELVIN [K]**

Section C: Waves and Optics

1. **General Wave Properties**
   - Transverse and longitudinal waves
   - Wave parameters: amplitude, wavelength, frequency, period, and velocity
   - Wave behavior: reflection, refraction, diffraction, and interference
2. **Sound**
   - Production and transmission of sound waves
   - Characteristics of sound: pitch, loudness, and quality
   - Doppler effect
3. **Light**
   - Reflection at plane and curved surfaces
   - Refraction and refractive index
   - Total internal reflection and critical angle
   - Lenses: types, image formation, and applications
4. **Electromagnetic Spectrum**
   - Components of the electromagnetic spectrum
   - Properties and uses of different regions of the spectrum

🌊 SECTION C: WAVES AND OPTICS

1. General Wave Properties

Subtopic	Explanation
Definition of a Wave	A disturbance that transfers energy from one point to another without the transfer of matter.
Types of Waves	Transverse: particles move perpendicular to wave direction (e.g. light). Longitudinal: particles move parallel to wave direction (e.g. sound).
Wave Terms	Wavelength (λ), frequency (f), period (T), amplitude (A), wave speed (v).
Wave Equation	$v = f\lambda$
Wave Behavior	Reflection, refraction, diffraction, interference.

Table: Wave Quantities

Quantity	Symbol	Unit	Definition
Wavelength	λ	metre (m)	Distance between two consecutive crests or troughs
Frequency	f	hertz (Hz)	Number of waves per second
Period	T	second (s)	Time for one complete wave ($T = 1/f$)
Amplitude	A	metre (m)	Maximum displacement of a particle from rest
Wave Speed	v	m/s	Speed = frequency × wavelength ($v = f\lambda$)

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2. Sound

Subtopic	Explanation
Nature of Sound	Longitudinal mechanical wave; requires a medium (solid, liquid, gas).
Production of Sound	Caused by vibrating sources (e.g., vocal cords, tuning fork).
Transmission	Travels fastest in solids, slower in liquids, slowest in gases. Cannot travel in a vacuum.
Characteristics	Pitch (frequency), Loudness (amplitude), Quality (waveform).
Speed of Sound	Approx. 340 m/s in air at room temperature.
Doppler Effect	Apparent change in frequency due to relative motion of source and observer.
Reflection of Sound	Echoes occur when sound reflects from a surface. Echoes require at least 0.1 s delay (≈17 m round trip).

3. Light

Subtopic	Explanation
Nature of Light	**Transverse electromagnetic wave; can travel in a vacuum at speed of 3.0×10^8 m/s.**
Reflection	**Follows the law: Angle of incidence = angle of reflection.**
Refraction	**Bending of light when it moves between media of different densities.**
Refractive Index (n)	**Ratio of speed of light in vacuum to speed in medium: $n = c/v$ or $n = \sin(i)/\sin(r)$**
Critical Angle & Total Internal Reflection (TIR)	**Occurs when light moves from denser to rarer medium. If angle of incidence > critical angle, light is totally reflected.**
Lenses	**Converging (convex) and diverging (concave). Used to form real or virtual images.**
Image Formation by Lenses	**Depends on object distance. Ray diagrams help determine nature of image (real/virtual, inverted/upright, magnified/reduced).**

Table: Image Characteristics for Convex Lens

Object Position	Image Nature
Beyond 2F	**Real, inverted, reduced**
At 2F	**Real, inverted, same size**
Between F and 2F	**Real, inverted, magnified**
At F	**No image (rays parallel)**
Between lens and F	**Virtual, upright, magnified**

4. Electromagnetic Spectrum

Subtopic	Explanation
Definition	A family of waves that travel at the speed of light in vacuum and do not need a medium.
Order of Spectrum	Radio → Microwaves → Infrared → Visible Light → Ultraviolet → X-rays → Gamma rays.
Wavelength & Frequency	As wavelength ↓, frequency and energy ↑.
Uses and Dangers	Each region of the spectrum has important applications and potential risks.

Table: Electromagnetic Spectrum

Type	Wavelength Range	Use	Risk
Radio waves	>1 m	Broadcasting, communication	None known
Microwaves	1 mm – 1 m	Cooking, mobile phones	Internal heating of body tissue
Infrared	700 nm – 1 mm	Remote controls, heaters	Burns
Visible Light	400–700 nm	Vision, photography	Bright light can damage eyes
Ultraviolet	10–400 nm	Sterilization, tanning	Skin cancer, eye damage
X-rays	0.01–10 nm	Medical imaging	Can cause cell damage
Gamma rays	<0.01 nm	Cancer treatment, sterilization	High cell damage, mutations

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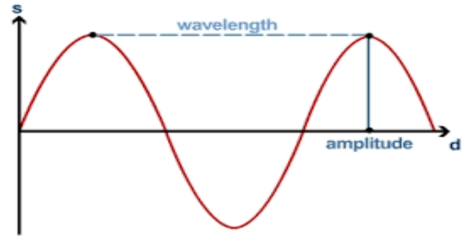
5. Reflection and Refraction (Reinforced)

Law or Concept	Explanation
Law of Reflection	$i = r$ (angle of incidence = angle of reflection)
Snell's Law	$n = \sin(i)/\sin(r)$ or $n_1\sin(i) = n_2\sin(r)$
Critical Angle (c)	$\sin(c) = n_2/n_1$ (only if $n_1 > n_2$)
Total Internal Reflection	Occurs if angle of incidence > critical angle; used in fiber optics.

Waves

Waves carry energy from one place to another.

1. Transverse: vibrate perpendicular to direction of motion. E.g. light waves
2. Longitudinal: vibrate parallel to direction of motion. E.g. soundwaves



a- amplitude

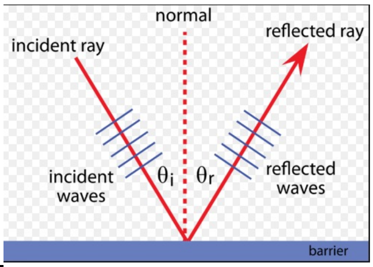
T- period

F- frequency: T = $\frac{1}{F}\,(H_z)$

λ- wavelength

v= f λ – speed

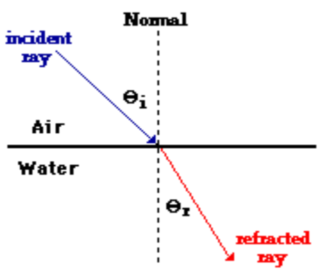
Reflection



Laws:

- i = r
- normal, incident at reflected ray lie on the same plane

Refraction



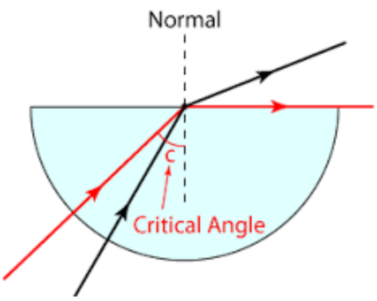
$\Theta_i > \Theta_r$ (ray slows down)

Snell's Law: Refractive Index,

$$n = \frac{\sin i}{\sin r} = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2}$$

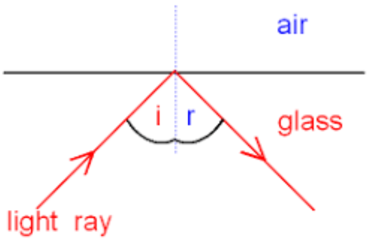
NB: Frequency is constant

Critical Angle



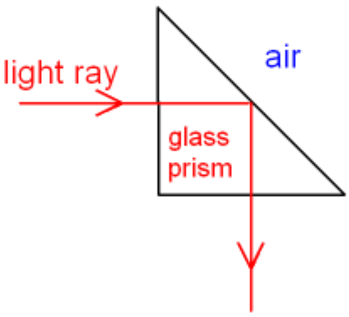
c= $\sin^{-1}\left(\frac{1}{n}\right)$

Total Internal Reflection

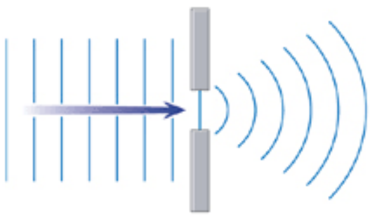


- i > c
- ray must be in denser medium

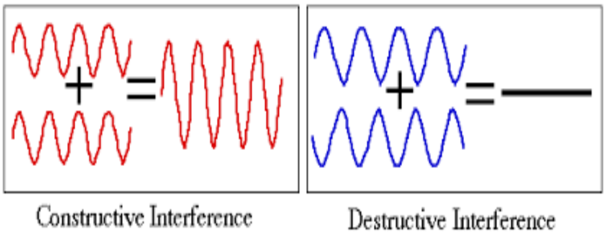
Example: Triangular Glass Prism



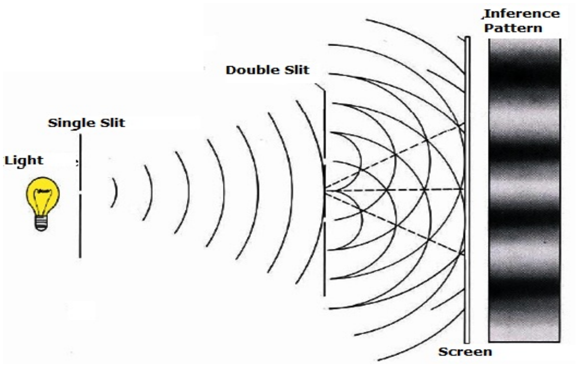
Diffraction- is the spreading of a wave as is passing through an opening that is comparable to its wavelength.



Interference-when lights falls on two narrow slits very close together.



Young's Double Slit



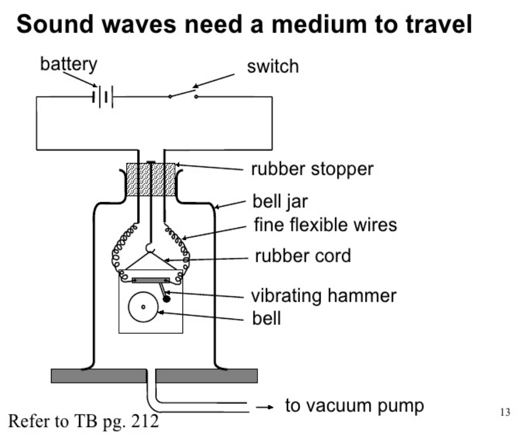
Electromagnetic Waves

WAVELENGTH INCREASES

1. speed of light, c= 3 * 10^8 ms^{-1}
2. through a vacuum
3. all transverse waves

Soundwaves

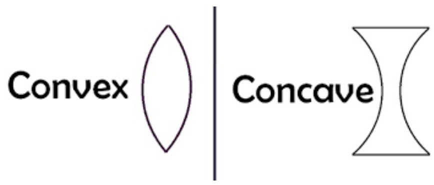
A wave of compression and rarefaction, by which sound is propagated in an elastic medium such as air.

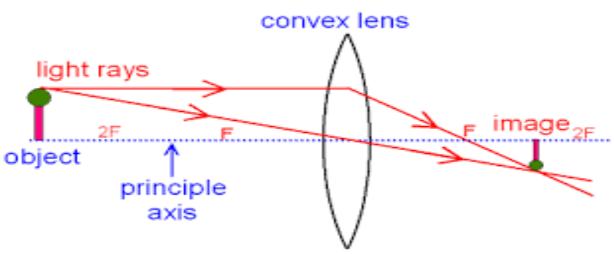


Lenses

Convex lens- is the thickest in the center and is also called a converging lens

Concave or diverging lens is the thinnest in the center and spreads light out.





Image

- Real or Virtual
- Max, Min, Same
- Upright or Inverted
- Position

Magnification = $\frac{image\ height}{object\ height}$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Section D: Electricity and Magnetism

1. **Electrostatics**
   - Charge, conductors, and insulators
   - Laws of electrostatics
   - Electric field and potential
2. **Current Electricity**
   - Electric current, potential difference, and resistance
   - Ohm's law
   - Series and parallel circuits
   - Electrical energy and power
3. **Magnetism**
   - Magnetic materials and properties
   - Magnetic fields and field lines
   - Earth's magnetic field
4. **Electromagnetism**
   - Magnetic effect of a current
   - Force on a current-carrying conductor
   - Electromagnetic induction
   - Transformers and their applications
5. **Electronics**
   - Diodes and rectification
   - Transistors and simple circuits
   - Logic gates and truth tables

⚡ SECTION D: ELECTRICITY AND MAGNETISM

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1. Electrostatics

Subtopic	Explanation
Electric Charge	There are two types: positive (+) and negative (−). Like charges repel, unlike charges attract.
Conductors and Insulators	Conductors (e.g., metals) allow electrons to flow freely. Insulators (e.g., plastic) do not.
Charging by Friction, Conduction, Induction	Friction: rubbing objects transfers electrons. Conduction: direct contact transfers charge. Induction: charging without contact using electric fields.
Electric Fields	A region around a charge where another charge experiences a force. Represented by field lines.
Field Lines	Point away from +ve charges and toward -ve charges. Never cross. Closer lines = stronger field.

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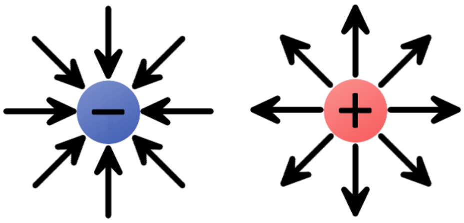
2. Current Electricity

Subtopic	Explanation
Electric Current (I)	Flow of charge per unit time: $I = Q/t$, measured in amperes (A).
Potential Difference (V)	Energy per unit charge: $V = W/Q$, measured in volts (V).
Resistance (R)	Opposition to current flow: $R = V/I$, measured in ohms (Ω).
Ohm's Law	$V \propto I$ when temperature is constant: $V = IR$.
Resistors in Series and Parallel	Series: $R_t = R_1 + R_2 + ...$ Parallel: $1/R_t = 1/R_1 + 1/R_2 + ...$
Voltage and Current in Circuits	Series: same current, voltages add. Parallel: same voltage, currents add.
Energy and Power	Power: $P = IV$, Energy: $E = IVt$ (Joules).
Electrical Safety	Fuses, circuit breakers, earthing, double insulation protect users and devices.

Electricity

A form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current.

Charges



Unlike charges attract **Like charges repel**

Q= It (C)

Static Electricity

A stationary electric charge, typically produced by friction, which causes sparks or crackling or the attraction of dust or hair.

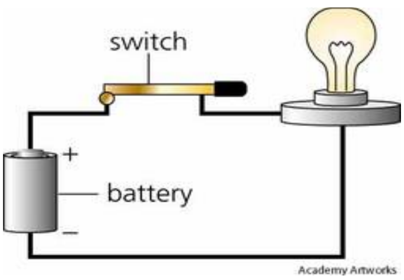
Static Charge

- Friction
- Conduction

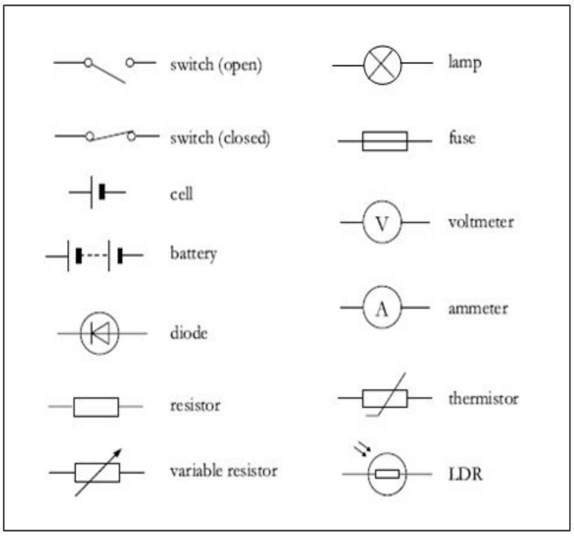
Current, I

I = $\frac{Q}{t}$ (A)

- Charge flowing per unit time



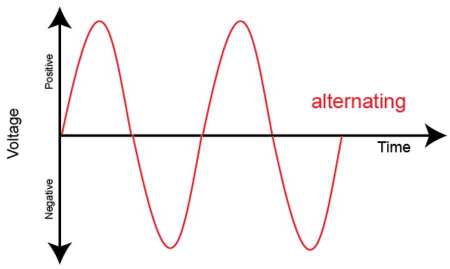
Symbols



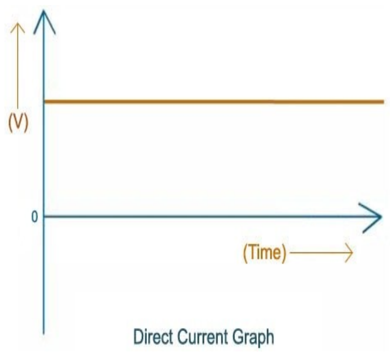
Current Electricity

Supply

AC

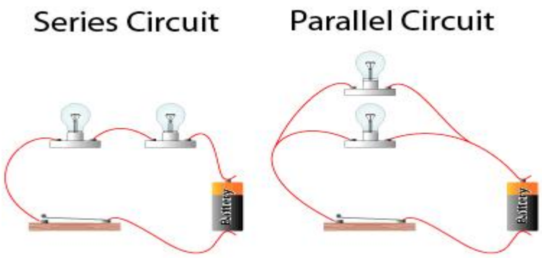


DC

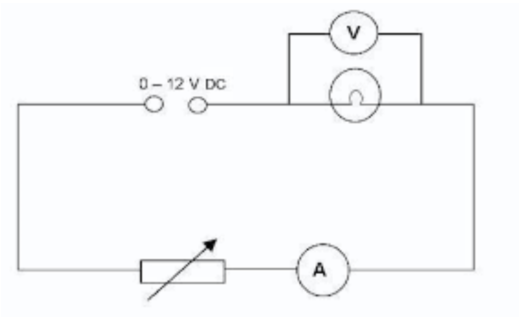


Circuits and Components

Series and Parallel Circuits

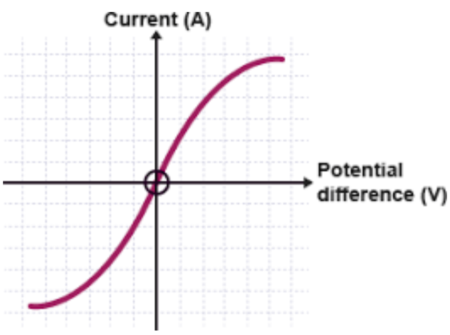


I- V Characteristics

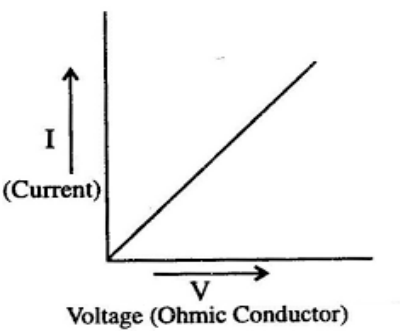


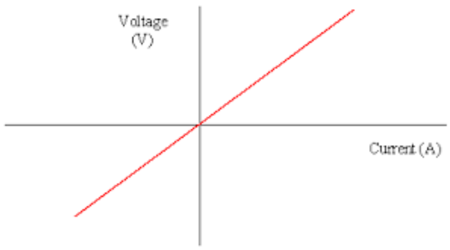
The above is circuit is used to determine the I-V characteristics of an electrical component.

Filament Lamp



Metallic Conductor





M = Resistor

Ohm's Law = R = $\frac{v}{I}$

V = IR

Other formulae:

W = QV

W = VIT

P= IV

P = $\frac{v^2}{R}$

P = I^2R (Power Loss)

	Series	**Parallel**
I	Same	Splits up
V	Splits up	Same
R	$R_T = R_1 + R_2 + R_3$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Bills

1 unit => 1 KWh

E => P * T

3. Magnetism

Subtopic	Explanation
Magnetic Materials	**Attracted to magnets: iron, steel, cobalt, nickel.**
Magnetic Fields	**The region where magnetic forces act. Represented by field lines from N → S pole.**
Earth's Magnetic Field	**Behaves like a giant bar magnet tilted from its geographic axis. A compass aligns with this field.**
Magnetization and Demagnetization	**Magnetization: stroking with a magnet, electric current.** **Demagnetization: heating, hammering, or alternating current.**
Permanent vs Temporary Magnets	**Permanent: retains magnetism (e.g., steel).** **Temporary: easily magnetized/demagnetized (e.g., soft iron).**

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4. Electromagnetism

Subtopic	Explanation
Magnetic Effect of a Current	**A current-carrying wire produces a magnetic field (right-hand rule). Stronger when coiled (solenoid).**
Electromagnets	**A soft iron core inside a solenoid increases magnetic strength. Used in bells, relays, MRI.**
Force on a Conductor (Motor Effect)	**A current in a magnetic field experiences a force: $F = BIL \sin\theta$ (Fleming's left-hand rule).**
DC Motor	**Converts electrical energy to mechanical energy. Based on interaction between current and magnetic field.**
Electromagnetic Induction	**A voltage (EMF) is induced when a conductor moves through a magnetic field.**
Faraday's Law	**Induced EMF is proportional to the rate of change of magnetic flux.**
Lenz's Law	**Induced current opposes the change that caused it.**
AC Generator	**Converts mechanical energy to electrical energy. Induces current by rotating a coil in a magnetic field.**
Transformers	**Change voltage using electromagnetic induction. Step-up (↑voltage) and step-down (↓voltage) types. Only work with AC.**

Transformer Formula:

$V_1/V_2 = N_1/N_2$

Where:

- **V = voltage**
- **N = number of turns**
- **Subscripts 1 = primary, 2 = secondary**

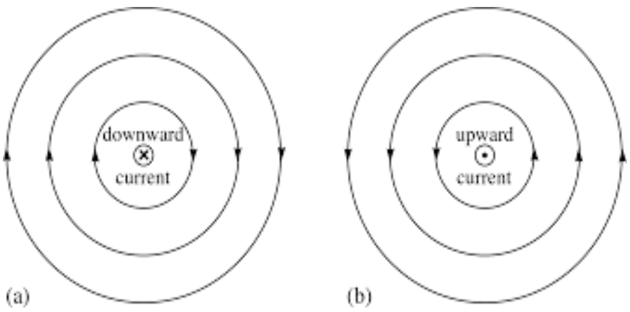
Magnetism

Around a magnet there is a magnet field that moves from the north to the south pole. A magnetic field is defined as region around a magnetic field where a magnetic force is experienced.

Magnetic flux is the magnetic field lines per unit area.

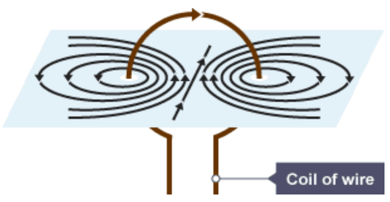
Like poles repel, unlike poles attract

Magnetic field lines around current carrying conductor

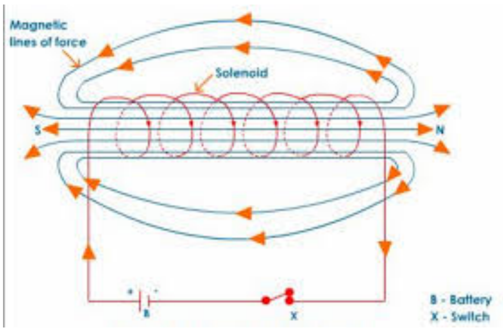


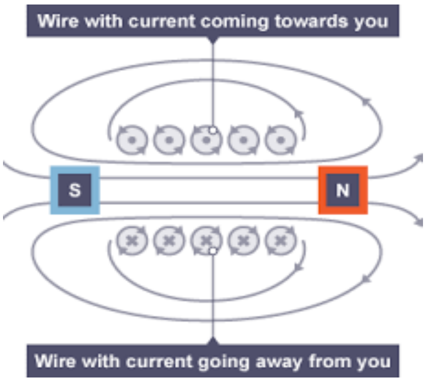
Flemings righthand screw rule.

Flat Circular Coil

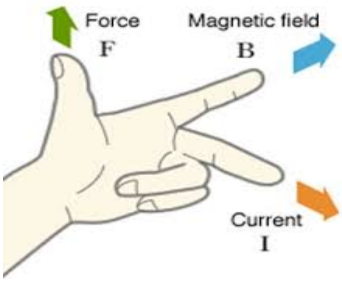


Solenoid



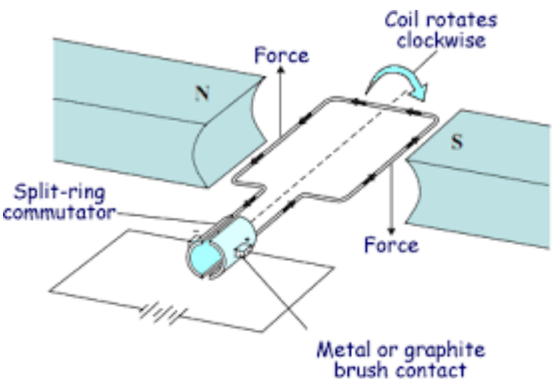


Fleming's Left Hand Rule (motor rule)

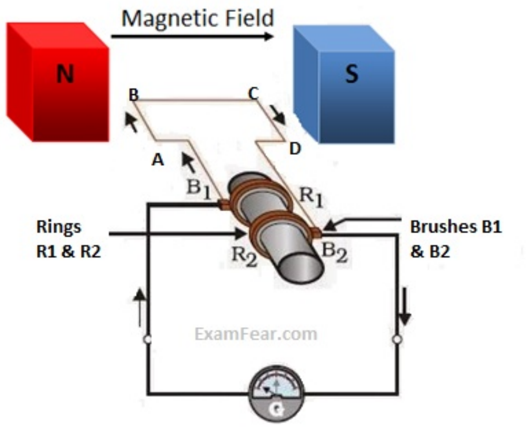


Currents Carrying Conductor In A Magnetic Field

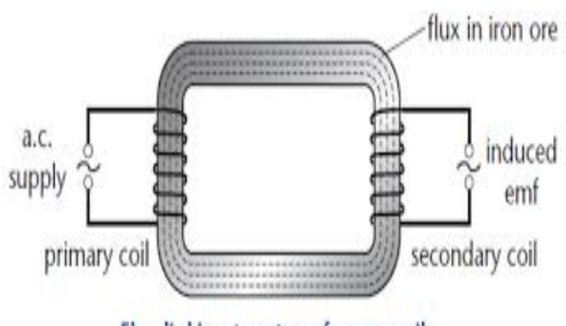
Motor



Generator



Transformer



Flux linking two transformer coils

$N_p > N_s$ step down transformer

$N_s > N_p$ step up transformer

$\frac{n_p}{n_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$

Faraday Law states that the rate at which the magnetic field lines cuts the solenoid/ conductor the greater is the e.m.f induced

Lenz' Law is the direction of the induced current always opposes motion.

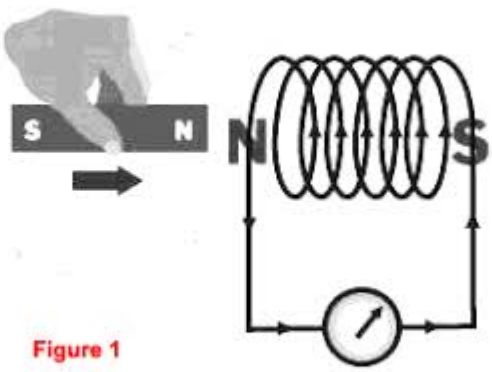


Figure 1

5. Electronics

Subtopic	Explanation
Diodes	Allow current to flow in one direction only. Used in rectifiers (convert AC to DC).
Rectification	Using diodes to convert alternating current (AC) into direct current (DC).
Transistors	Amplify or switch electronic signals. Two main types: NPN and PNP.
Logic Gates	Basic digital components that follow Boolean logic.
Types of Logic Gates	AND, OR, NOT — combine digital signals to produce specific outputs.

Truth Tables for Basic Gates

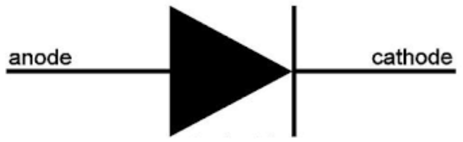
A	B	AND	OR
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	1

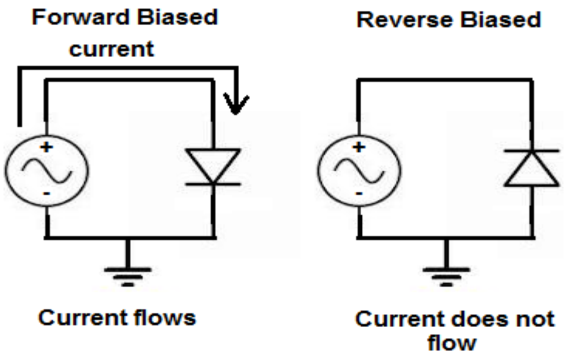
NOT Gate:

A	NOT A
0	1
1	0

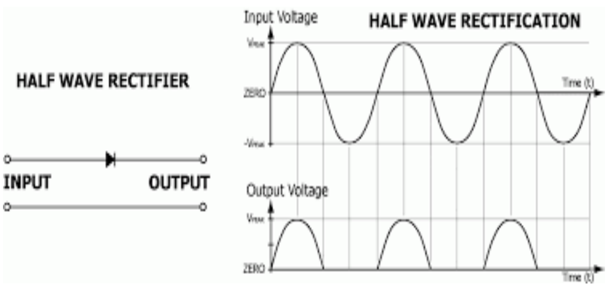
Electronics

Diode

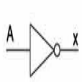
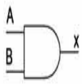
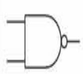
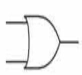
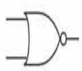




Half- Wave Rectification



Logic Gates

Name	NOT	AND	NAND	OR	NOR
Alg. Expr.	$\overline{A}$	AB	$\overline{AB}$	$A+B$	$\overline{A+B}$
Symbol					

Section E: The Physics of the Atom

1. **Structure of the Atom**
    - Subatomic particles: protons, neutrons, and electrons
    - Nuclear structure and notation
2. **Radioactivity**
    - Types of radiation: alpha, beta, and gamma
    - Properties and detection of radiation
    - Half-life and radioactive decay calculations
    - Applications and hazards of radioactivity
3. **Nuclear Energy**
    - Mass-energy equivalence
    - Nuclear fission and fusion
    - Applications

🧬 SECTION E: THE PHYSICS OF THE ATOM

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1. Structure of the Atom

Subtopic	Explanation
Atoms and Subatomic Particles	Atoms are composed of protons (+), neutrons (0), and electrons (−). Protons and neutrons are in the nucleus; electrons orbit the nucleus.
Atomic Number (Z)	Number of protons in the nucleus. Determines the identity of the element.
Mass Number (A)	Total number of protons and neutrons in the nucleus: **A = Z + N**
Isotopes	Atoms of the same element with the same number of protons but different numbers of neutrons.
Nuclear Notation	Represented as:

ZAX{}^{A}_{Z}\text{X}ZAX

Where X = element symbol, A = mass number, Z = atomic number. |

Table: Subatomic Particles

Particle	Symbol	Charge	Mass (kg)	Location
Proton	p^+	+1	1.67×10^{-27}	Nucleus
Neutron	n^0	0	1.67×10^{-27}	Nucleus
Electron	e^-	−1	9.11×10^{-31}	Electron shells

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2. Radioactivity

Subtopic	Explanation
Radioactive Decay	Spontaneous breakdown of unstable nuclei, emitting radiation.
Types of Radiation	**Alpha (α):** Helium nucleus ($^{4}_{2}He$). **Beta (β):** High-speed electron ($^{0}_{-1}e$). **Gamma (γ):** Electromagnetic radiation.
Properties of Radiation	Differ in mass, charge, penetrating power, and ionising ability.
Detection of Radiation	Geiger-Müller tube, photographic film, cloud chamber.
Decay Equations	Show changes in atomic and mass numbers. For example:

Comparison of Alpha, Beta, and Gamma Radiation

Type of Radiation	Symbol	Charge	Mass	Penetrating Power	Ionising Ability	Stopped By

Alpha (α)	$^{4}_{2}He$	+2	4 u	Low	High	Paper, skin, few cm of air
Beta (β^-)	$^{0}_{-1}e$	−1	~0	Medium	Medium	Aluminium sheet (few mm)
Gamma (γ)	γ	0	0	Very high	Low	Thick lead, concrete

Half-Life Formula: $N = N_0 \left[\frac{1}{2^n} \right]$

Where:

- N = number of undecayed nuclei remaining
- N_o = original number of nuclei
- n = number of half-lives elapsed

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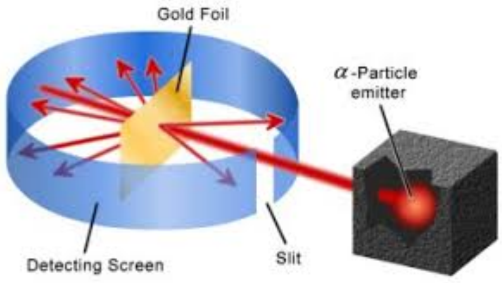
3. Nuclear Energy

Subtopic	**Explanation**
Mass-Energy Equivalence	Einstein's equation **E = mc²** shows mass can be converted to energy.
Nuclear Fission	Splitting of a heavy nucleus (e.g., uranium-235) into smaller nuclei, releasing energy and more neutrons. Basis of nuclear reactors.
Nuclear Fusion	Joining of light nuclei (e.g., hydrogen) to form heavier ones (e.g., helium), releasing more energy than fission. Powers the sun.
Comparison: Fission vs Fusion	Fission: controllable, used in power plants, produces waste. Fusion: cleaner, more energy, requires extreme conditions.
Applications of Nuclear Energy	Power generation, medical treatments (e.g., cancer radiotherapy), sterilisation of equipment, space probes.
Dangers	Radiation exposure, waste disposal, accidents (e.g., Chernobyl, Fukushima), potential weaponization.

Radioactivity

The emission of ionizing radiation or particles caused by the spontaneous disintegration of atomic nuclei.

Gold oil Experiment – Geiger and Marsden



Conclusion

- Empty space
- Small positive core
- Small dense core

$$^{A}_{Z}X$$

A – mass/ number of nucleon

Z- atomic/ umber of protons

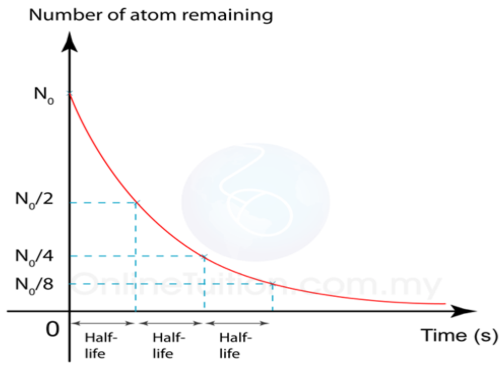
Types of radiation:

1. Alpha- α : $^{4}_{2}He^{2+}$
2. Beta- β : $^{0}_{-1}e^{-1}$
3. $Gamma - ray\ \gamma$: energy

	Stopped by	Range in Air
α	Paper	cm
β	Al	m
γ	Ld	Km

Half – Life

The time taken for half of a present element to decay.



Fraction Left: $\frac{1}{2^n}$

n – number of half lives

Einstein energy mass-relationship

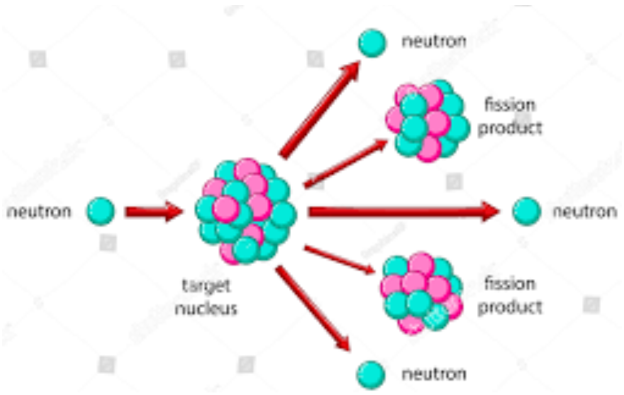
$E = \Delta mc^2$

$\Delta m = m_r - m_p$

$C = 3 * 10^8 ms^{-1}$ (speed of light)

Nuclear Fission

A nuclear reaction in which a heavy nucleus splits spontaneously or on impact with another particle, with the release of energy.



Nuclear Fusion

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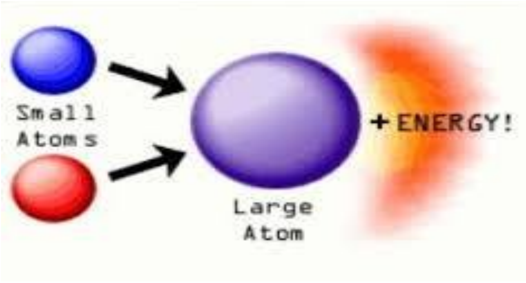

Radioisotopes Uses

- Carbon Dating
- Treating Cancer
- tracer