Unit 2: Mechanics

4 Fundamental Forces

1. **Gravitational:** The effect produced by the force of attraction between all masses in the universe
2. **Electromagnetic:** Is a type of physical interaction that occurs between electrically charged particles. The magnetic force acts between the moving particles. Every charged particle gives off an electric field whether moving or not. (e.g. radio and television waves, microwaves, infrared rays, etc)
3. **Strong nuclear:** Occurs in atoms' nucleolus. Since neutrons have no charge it binds protons and neutrons to the nucleons into atomic nuclei keeping the electrons in orbit. (e.g. force that binds protons and neutrons in nuclei of atoms)
4. **Electroweak:** It is responsible for radioactive decay but is only effective at doing so from short distances. Helps in the formation of new elements.

Difference between mass & weight

Mass is the amount of matter in an object (kg) whereas weight is a force due to the pull of gravity an due to the pull gravity an object (Newton)

Resulting forces

When two forces acting on an object are not equal in size, they are unbalanced forces. If the forces are balanced and the resultant force is zero the object will stay at rest. If the forces on an object are unbalanced, the stationary object starts to move in the direction of the resultant force.

Scaler and vector

A vector quantity is a physical quantity that has magnitude and direction. A scalar quantity has magnitude but no direction. A vector quantity can be represented by an arrow in the direction of the vector and of length in proportion to the magnitude of the vector. (For example, speed is a scalar quantity and velocity is a vector quantity)

Contact forces (forces that act between 2 objects that are physically touching)

Normal – support force exerted upon an object that is in contact with another stable object
Tension – it is a pulling force exerted by each end of an object like a rope
Friction – 2 objects sliding past each other and are experiencing friction forces
Air resistance – it is a force that is produced when an object moves through the air like a drag
Drag - When a solid object moves through a fluid it will experience the drag force, opposing its motion.

Non-Contact forces (forces that act between 2 objects that are physically touching)

Magnetic – experienced by a magnetic material in a magnetic field
Electrostatic - experienced by a changing particle in an electric field

Other forces

Applied – force applied to objects by a person or another object
Spring – force exerted by compression/stretched spring upon any object that is attached to it

Unit 3: Speed and Acceleration

Definitions

1. **Distance**: Distance is a numerical measurement of how far apart objects or points are.
2. **Displacement:** The distance (or displacement) in work is the distance from the start point to the endpoint. travel in between does not matter. It is dependent on the direction an object moves For example, if you lift a weight off the ground and then place it back on the ground the distance (or displacement) is zero.
3. **Speed:** The speed of an object can be thought of as the rate at which it covers distance. Speed is a scalar quantity.
4. **Velocity:** Velocity is the rate of change in an object's position. Velocity has a magnitude (speed) and a direction. Velocity is a vector quantity. **V = D/T**. Terminal velocity is when the downward force is equal to the upwards force.
5. **Acceleration:** Acceleration is the rate at which velocity changes with time, in terms of both speed and direction. A point or an object moving in a straight line is accelerated if it speeds up or slows down.

The gradient is the speed in a **distance-time graph**
The gradient is the acceleration is a **velocity-time graph**

A= final velocity - starting velocity/time
Average speed = total time / total distance

Unit 4: Forces and Gravity

Newton's 3 laws of Motions

1. An object will not change its motion unless acted on by an unbalanced force. (Interia- Os when objects want to stay in rest or motion unless an outside force causes a change.)
2. When a constant force acts on a massive body, it causes it to accelerate, i.e., to change its velocity, at a constant rate. (Example riding your bike, the bike is the mass. Your legs are pushing on the pedals making a force which causes it to accelerate) - **F = M x A**
3. When two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction. Forces always come in pairs of equal and opposite action-reactions (For example, for every reaction there is an equal and opposite reaction)

How Unbalanced forces cause Acceleration

→ The overall unbalanced force is called the resultant force. It will always produce acceleration or deceleration.
→ Acceleration takes place through either, starting, stopping, speeding up, slowing down, and changing direction.
→ An unbalanced force is a force acting on an object that causes it to accelerate. Bigger force = bigger acceleration

Freefall

→Freefall is a kind of motion. Any object that is falling under some influence of gravity is in a state of free fall.
→ Free-falling objects do not experience air resistance.
→ All free-falling objects on earth accelerate downwards at 9.8m/s2. - The heavier the object the faster it falls.
→ All objects in a vacuum fall at the same rate of accelerating independently of mass

Momentum

→ Momentum is a vector quantity; it has both magnitude and direction.
→ Momentum is defined as the amount of motion occurring in something that is moving, or the force that drives something forward to keep it moving.
→ An example of momentum is how quickly a car is moving down a hill.

Law of conservation of momentum

The law states that when two objects collide in a closed system, the total momentum of the two objects before the collision is the same as the total momentum of the two objects after the collision.

Unit 5: Force System

Different Energy Types

1. **Chemical Energy** - Combustion reaction converts chemical energy into light and heat
2. **Thermal Energy** - The warmth from the sun
3. **Nuclear Energy** - Nuclear Fusion
4. **Electrical Energy** - A lamp is plugged into a wall outlet
5. **Magnetic Energy** - Compass

Define Kinetic and gravitational potential energy

1. **Kinetic Energy:** Energy an object has due to its motion. As long as an object is moving at the same velocity, it will maintain the same kinetic energy. Affected by mass and speed
2. **Gravitational Energy:** Energy that is stored because of an object's position or height above the Earth's surface. Gravity is the force of attraction that pulls objects together and causes things to fall to Earth. Affected by mass, gravity, and height

Work

Work is done when a force moves something in any direction (Everyday examples of work include walking upstairs, lifting heavy objects, pulling a sledge, and pushing a shopping trolley.) Whenever work is done, energy is transferred from one place to another.

1. **Positive work** follows when the force has a component parallel to the displacement. Positive work adds energy to a system.
2. **Negative work** is when the force has a component opposite or against the displacement.

Formulas

Work = Force • Displacement • Cosine(theta)
Power = Work/time.
GPE = m in kg • g (on earth 9.8) • height.
Kinetic Energy = 0.5 • meters • velocity^2

Efficiency

Energy efficiency measures the proportion of energy that is wasted. The rate at which energy is wasted needs to be reduces **Output ÷ Input x 100**

Unit 6: Heat and Power

Heat and Temperature

1. **Internal energy** is the total energy stored in the particles of a substance, including kinetic and potential energy. It is a measure of the microscopic energy of a substance. Measured in Joule (J)
2. **Thermal energy** is the energy associated with the temperature of a substance, and it is a measure of the total kinetic energy of all the particles in the substance.
3. **Heat** is the transfer of thermal energy between two substances that are at different temperatures. It is the energy that flows from a warmer substance to a cooler substance. Measured in Joule (J)
4. **Temperature** is the average kinetic energy of the particles in a substance. It describes how hot or cold a substance feels. Measured in Celcius (C) or Kevlin (K). **(K) = (°C) + 273.15**

Absolute Zero.

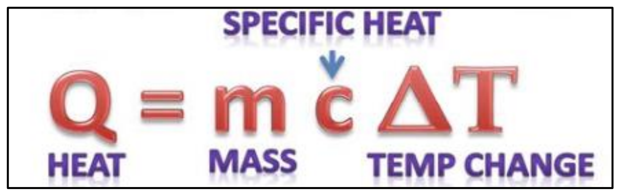
The lowest possible temperature that can theoretically be achieved, at which point all particles would be at their minimum possible energy state also, at this temperature, all molecular motion would stop completely.

Heating and Cooling

- Heat transfer causes the particles in an object to gain or lose energy, which changes the molecular structure and movement of particles.
- The particles gain kinetic energy, vibrate faster, and move farther apart when heated, and lose kinetic energy, slow down, and move closer together when cooled.

Specific Heat Capacity

Specific heat capacity is the amount of heat energy required to raise the temperature of one unit of mass of a substance by one degree Celsius



States of Matter

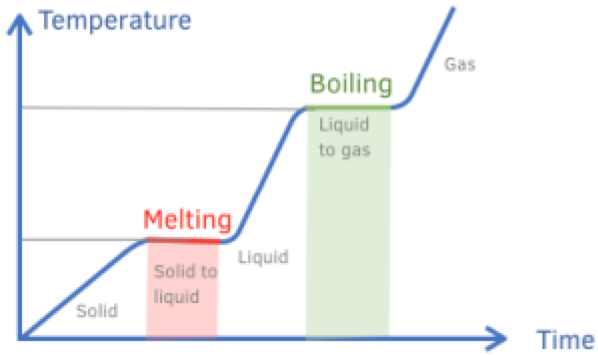
Solid:	Liquid:	Gas:
Atom arrangement: particle movement is rigid, instead vibrates → tightly packed atoms.	Atom arrangement: Irregular pattern; takes shape of the container → strongly attracted to each other + they tend to slide past each other.	Atom arrangement: Spread out; irregular arrangement; spaced out through container → particles can pass one another and are compressible.
Properties: Definite shape and volume; hard → atoms are closely packed together + chemically bonded.	Properties: No definite shape; fixed volume; can flow; uncompressed easily (e.g. water).	Properties: Indefinite shape or volume (e.g. helium gas) → can be compressed.
Density: Relatively dense → proximity of atoms.	Density: Less dense than a solid, but denser than gas → Particles are less fixed + uncompressed easily.	Density: Least dense state of matter → easily compressed + extremely spaced out.

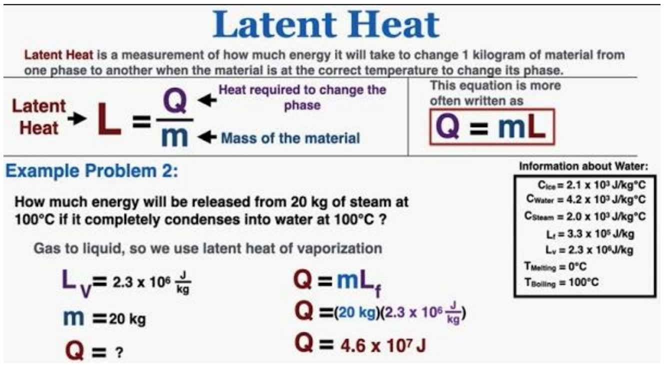
Internal Energies of matter for solids, liquids and gases.

Solids have the lowest kinetic energy so vibrate very little. Liquids have more kinetic energy so particles slide past each other. Gases have the most kinetic energy so fly around in the air.

Energy changes that take place during a change of state with reference to Latent Heat.

During a change of state, energy is absorbed or released without a change in temperature. This energy is known as latent heat and is required to break or form intermolecular bonds between the particles of the substance. When a substance changes from solid to liquid or liquid to gas, heat is absorbed, while the reverse processes release heat.





Explain why the Internal energy of gases is stored as Kinetic Energy only.

The internal energy of gases is stored as kinetic energy only because gases consist of a large number of molecules that are in constant random motion. The temperature of the gas is a measure of the average kinetic energy of its molecules, where the kinetic energy is related to the mass and velocity of the molecules.

Describe the process of evaporation.

Evaporation is the process where a liquid turns into a gas due to the absorption of heat energy, causing the molecules to gain enough kinetic energy to break away from the liquid and enter the air as a vapor.

Thermal Insulation

Conduction: Materials with low thermal conductivity, like insulation materials or air, can prevent heat transfer by slowing down the transfer of heat from one object to another through direct contact.

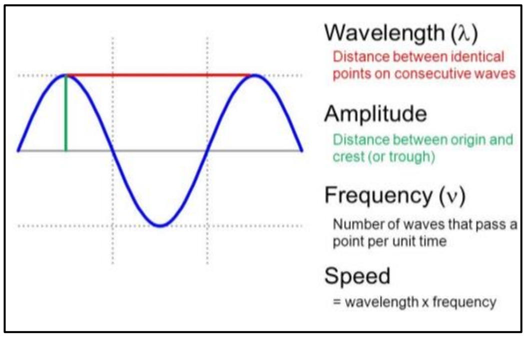
Convection: Materials with low thermal conductivity can also prevent heat transfer by inhibiting the movement of heat through fluids, like air or water, which limits convection currents.

Radiation: Materials with high reflectivity or low emissivity, like shiny metal or reflective film, can prevent heat transfer by reflecting or redirecting thermal radiation away from the object, reducing the amount of heat absorbed.

Unit 7: Waves

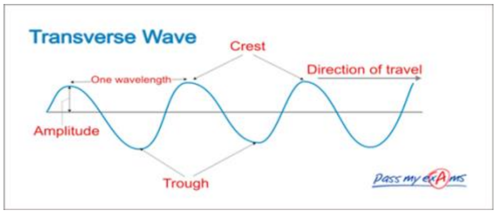
Definitions

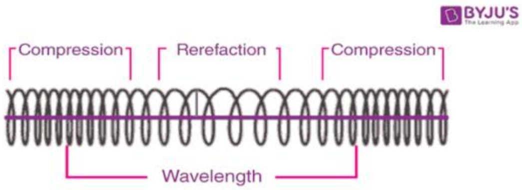
5. **Wave:** A wave can transfer energy and information without transferring matter. It completes an oscillation is a repeating back-and-forth movement
6. **Amplitude:** It is the maximum or min displacement from the equilibrium of the wave
7. **Wavelength:** The wavelength is the distance from a point on a wave to the same point on a different wave **(V = F x WL)**
8. **Frequency:** It is the amount waves in a periodic motion that pass a point in a second measured in Hz **(1/T)**
9. **Time period:** It is the time taken to complete 1 oscillation (T)



Longitudinal and transverse wave motion.

1. Transverse waves are the transfer of energy in a motion that is perpendicular to the direction the wave is travelling. Ex: Tidal Waves
2. Longitudinal wave is a wave consisting of a periodic disturbance or vibration that takes place in the same direction as the advance of the wave. Made up of compression and rarefactions of particles. For example, a sound wave.





Wavefront and rays.

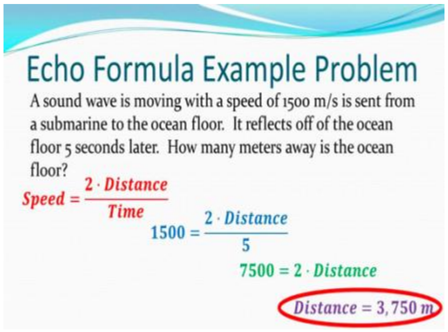
1. **A wavefront** is a surface of a constant phase.
2. **A ray** is a perpendicular line drawn at any point on the wavefront and represents the direction of propagation of the wave.

Sound of Waves

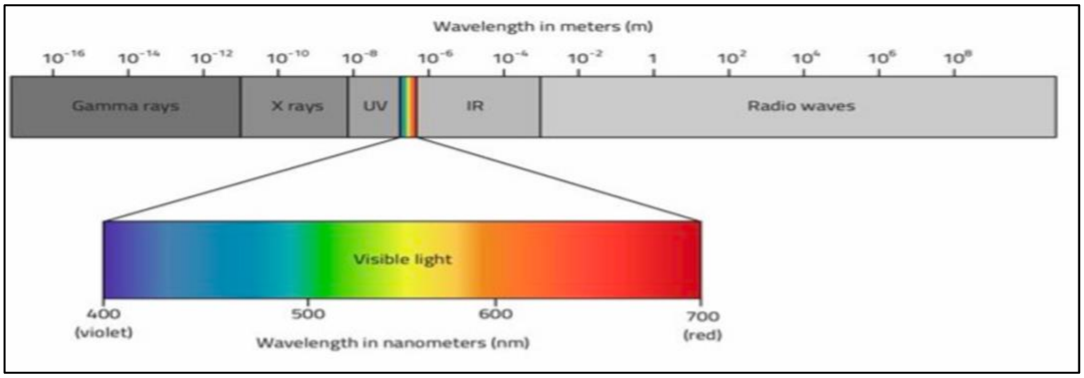
Higher pitch = higher frequency

Louder note = greater amplitude

- **The speed of sound in the air is around 330 to 340 m/s**
- Sound cannot be heard in a vacuum because it has essentially zero air. Because sound is just vibrating air, space has no air to vibrate and therefore no sound.
- Humans can hear sounds from 20 Hz to 20 kHz. They lose some high-frequency sensitivity as they grow older.
- **Ultrasound** refers to any sound waves with frequencies greater than 20kHz.



Electromagnetic Spectrum



From gamma onwards, frequency decreases and wavelength increases. There are some harmful effects of the EM spectrum such as gamma rays. This is because X-rays can cause cancer. **The speed of an electromagnetic wave in a vacuum is 3.0 x 10^8 m/s**

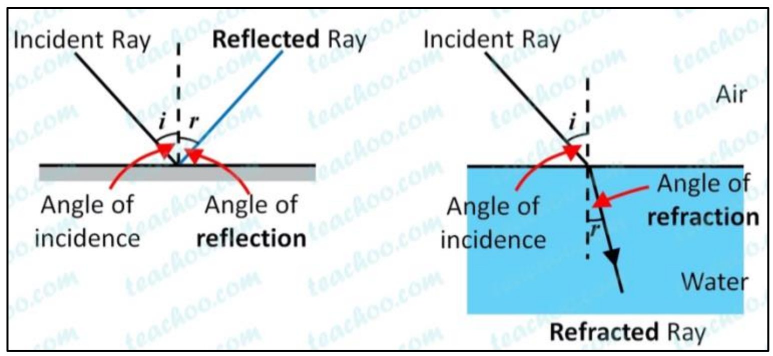
Light and color

What color means in relation to light is we see the different wavelengths as different colors. As the wavelength increases the color goes from violet to red. When a white light ray passes through a prism it disperses into seven different colours, and this phenomenon is called dispersion.

Reflection and Refraction

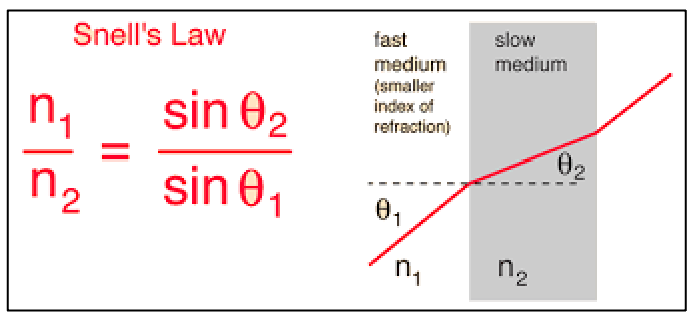
A wave can be transmitted, which means to pass through the object. It can be absorbed, in which the wave is converted to thermal energy, or it can be reflected and sent off in a new direction.

The Law of Reflection: angle of incidence = angle of reflection.



Refraction

- Caused by change of the speed of light in different mediums. Refraction is the bending of the path of a light wave as it passes from one material into another material. The refraction occurs at the boundary and is caused by a change in speed of the light wave upon crossing the boundary. (rare to dense: angle moves towards normal – eg: air to water/glass)
- Refractive index is the measure of the bending of a ray of light when passing from one medium into another. Air is always 1
- **N = C / V** (n = refractive index, c = is speed of light in vacuum (3 x 10^8), v = speed of light in medium)

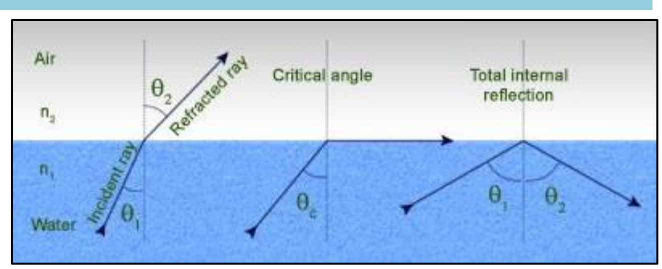


Total Internal Reflection.

- To find critical angle, mover incident ray until refracted ray is 90 (largest angle where refraction can still occur)
- Critical angle is angle of incidence. When incidence angle is larger, light is totally internally reflected, and no refraction will occur – Ray is entirely reflected in glass.

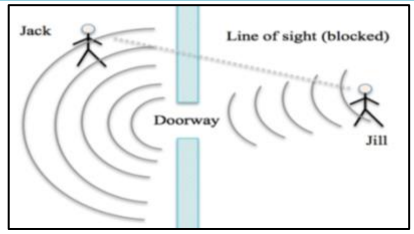
$$n = \frac{1}{\sin c}$$

Refractive index Critical angle

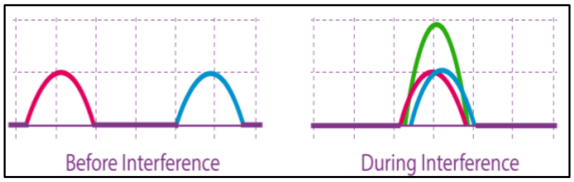


Diffraction and Interference

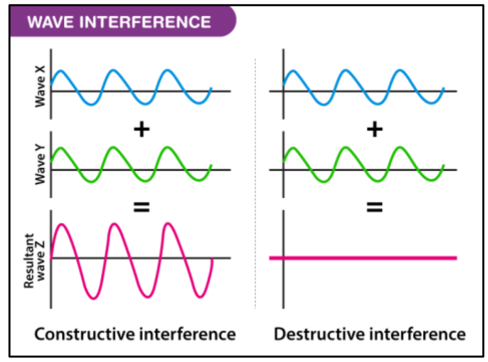
Waves are diffracted when they pass through a gap, so they spread out into space beyond the barrier. The biggest effect is caused the wavelength is equal to the gap. Light needs smaller gaps because of its smaller wavelength while sound needs a larger gap. Ex: Rock in the ocean



Interference of waves.



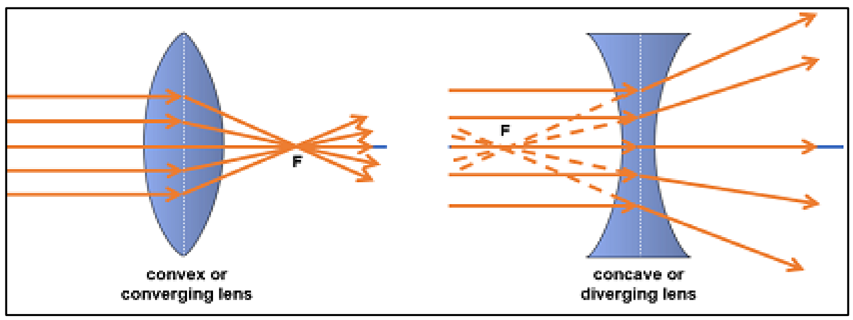
Wave interference is the phenomenon that occurs when two waves meet while traveling along the same medium. Produces a resultant wave.



In constructive interference, waves that are in phase will combine together and increase the amplitude. **In destructive interference**, waves are out of phase and cancel one another out. Noise cancellation uses ‘destructive interreference’ to cancel out the unwanted sound

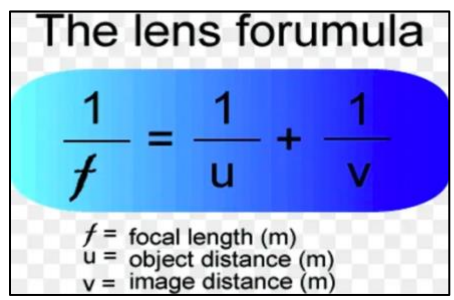
Optics

- Images formed by plane mirrors are virtual, upright, left-right reversed, the same distance from the mirror as the object's distance, and the same size as the object.
  1. **Converging lens** is convex lens that converges and focuses the light ray to meet at a single point. Used in telescopes
  2. **Diverging lens** is a concave lens that diverge the lights falling on its surface and not meet at a single point. Used in microscopes.



Behavior of converging and diverging lenses to find the focal point

Parallel rays of that pass through a convex lens are refracted so that they converge to a point (principal focus or the focal point) While in a concave lens, light refracted so that they diverge away from a point (principal focus). The distance from the center of the lens to the principal focus is the focal length.



Explain how lenses and mirrors are used in telescopes and magnifying glasses.

The light microscope and telescope use convex lenses and mirrors to make enlarged images of very tiny or distant objects. They also use mirrors and lenses to reflect and refract light and form images. A camera uses a convex lens to make a reduced image of an object.

Unit 8: Climate Change

Greenhouse gases.

The Earth has a natural greenhouse effect due to trace amounts of water vapor (H2O), carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in the atmosphere.

1. **Global warming**: The increased concentration of greenhouse gases in the atmosphere has led to an increase in the Earth's average surface temperature over the past century
2. **Changes in precipitation patterns:** As the Earth's temperature rises, the amount and distribution of rainfall and snowfall are also expected to change.
3. **Sea level rise:** The melting of glaciers and ice sheets, as well as the expansion of warming ocean water, is causing the global sea level to rise.
4. **Changes in extreme weather events:** The warming of the Earth's atmosphere is expected to increase the frequency and intensity of extreme weather events.
5. **Ecosystem changes:** The changes in temperature and precipitation patterns, as well as the increased frequency of extreme weather events, are likely to have significant impacts on natural ecosystems and the species that inhabit them.

Black Body and Albedo

1. **Black Body:** It is an ideal body that absorbs all incident electromagnetic waves or radiation, regardless of the angle of incidence or frequency. As it absorbs all colors of light, it is named as black "body".
2. **Albedo**: is the reflectivity of a surface and measure of how much of the incoming solar radiation is reflected back into space. An albedo of 0 means that the surface absorbs all incoming radiation, while an albedo of 1 means that the surface reflects all the incoming radiation. **Albedo = Reflected Light/Incoming Light.**

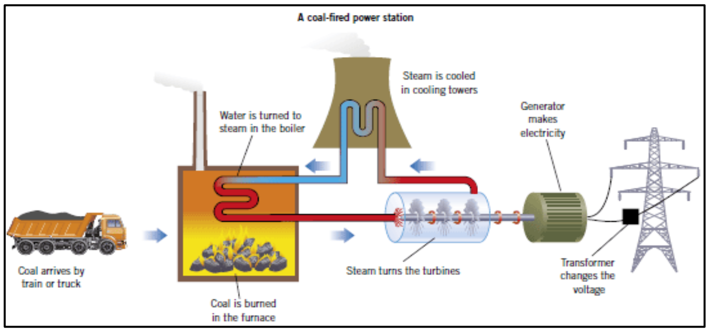
Energy sources

Primary energy consists of unconverted or original fuels. Secondary energy includes resources that have been converted or stored.

Renewable and non-renewable energy sources.

A renewable resource can be use again as there is an infinite supply of it. They have lower environmental impact and are becoming increasingly cost-effective. while a nonrenewable resource has a limited supply. Renewable resources include timber, wind, and solar while nonrenewable resources include coal and natural gas

Key features of a non-renewable fuel source power station:



- **The burning of fossil fuels** like coal, oil, and gas to generate electricity is a major contributor to greenhouse gas emissions.
- **Transportation**
- **Agriculture and Land Use:** Agricultural activities like livestock production,
- **Deforestation and land** use changes also contribute to greenhouse gas emissions.
- Since the industrial revolution, atmospheric concentrations of carbon dioxide (CO2) have increased. Other greenhouse gases, such as methane have also increased significantly due to human activities such as agriculture and fossil fuel.

Unit 9: Circuits and Electricity

Static Electricity

- A surplus or deficit of electrons in an object can lead to a static electric charge. When an object gains or loses electrons, it becomes positively or negatively charged.
- When two objects come into contact and are rubbed together, the electrons from one object may transfer to the other object.
- This transfer can occur because rubbing creates a force that can overcome the electrostatic attraction that holds electrons in place.
- Insulators can be statically charged more easily than conductors because they don't have free electrons that can move through the material
- In conductors, the free electrons can move through the material and neutralize any static charge. This is why conductors are not easily statically charged.

Voltage, Current, and Electric Circuits

1. **Electric current** is caused by the movement of a negative charge, i.e. electrons. The electrons move through a conductor under the influence of an electric field, carrying energy and information along the way.
2. **Charge** is the amount of electrical energy contained within an object. It is measured in coulombs (C) and is denoted by the symbol "Q".
3. **Voltage (or potential difference)** is a measure of the electric potential energy. It is measured in volts (V) and is denoted by the symbol "V".
4. **Current** is the flow of electrical charge through a circuit. It is measured in amperes (A) and is denoted by the symbol "I".

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

V = Potential Difference (Voltage)
I = Current
R = Resistance

Resistance

- **Resistance** is a measure of how much a material or component opposes the flow of electrical current. It is measured in units called ohms (Ω).
- The collision of moving charges with the atoms in a material causes resistance by creating obstacles in the path of the current flow, which increases the energy required for the current to pass through. And if the material is heated up then there would be more collisions thus the resistance would increase.

Factors that affect resistance including length, CSA and resistivity.

1. **Length:** The longer the length of a material, the greater the resistance. This is because the current must travel a longer distance, which means it has to overcome more obstacles in the material.
2. **Cross-sectional Area (CSA)**: The larger the CSA of a material, the lower the resistance. This is because a larger area provides more space for the current to flow, which means there are fewer obstacles for the current to overcome.
3. **Resistivity:** Resistivity is a measure of a material's ability to conduct electricity. Resistivity is affected by factors such as temperature, impurities in the material, and the atomic structure of the material.

Conductors and Insulators

1. **Conductors:** High electrical conductivity, low resistance, good heat conductivity. Ex: Copper, aluminum
2. **Insulators:** Low electrical conductivity, high resistance, poor heat conductivity. Ex: rubber, glass, plastic,

What is resistivity and conductivity?

1. **Resistivity** of a material is a measure of its inherent resistance to the flow of electric current and is measured in ohmmeters (Ω·m)
2. **Conductivity** is the measure of how well a material can conduct electricity.

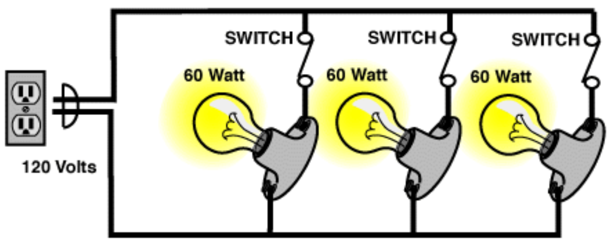
resistivity= 1/conductivity

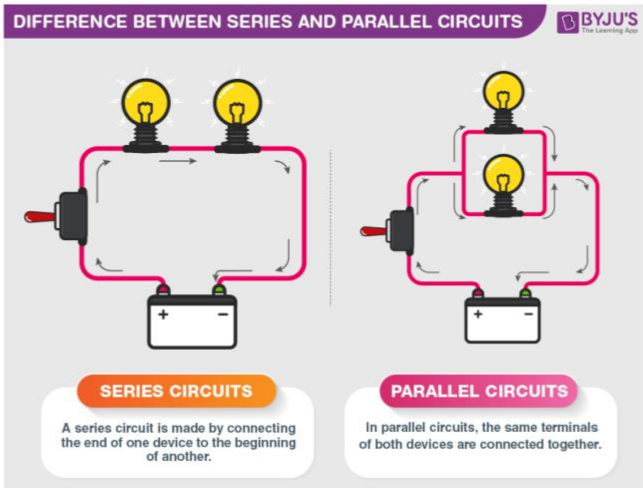
Series and Parallel circuits

Switches

In a simple series circuit, place the switch in the path of the current, allowing it to turn the current on and off.

In a parallel circuit, each switch can control the current flow to its branch. This allows multiple devices to be controlled independently.





How current, voltage and resistance vary in different parts of series and parallel circuits.

In a series circuit, the current remains constant throughout all components while the voltage is shared among them. The total resistance is equal to the sum of the individual resistances.

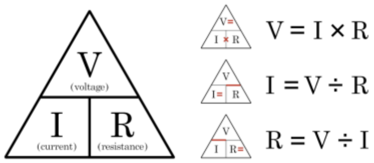
Series: Current $I_T = I_1 = I_2 = I_3$ Voltage $V_T = V_1 + V_2 + V_3$ Resistance $R_T = R_1 + R_2 + R_3$

In a parallel circuit, the voltage across each component is the same, and the total current is the sum of the currents through each component. The total resistance is less than the smallest individual resistance.

Parallel: Current $I_T = I_1 + I_2 + I_3$ Voltage $V_T = V_1 = V_2 = V_3$; Resistance $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$

Ohm's law

- Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points.



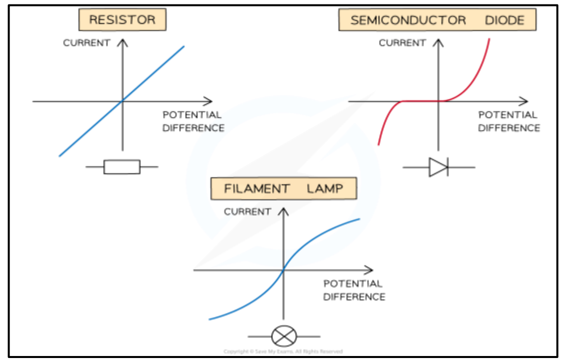
Ohmic and nonohmic conductors.

1. Ohmic conductors obey Ohm's law, where the current through them is directly proportional to the voltage applied, and their resistance is constant regardless of voltage or current.
Examples of ohmic conductors include most metals

2. non-ohmic conductors do not obey Ohm's law and have varying resistance concerning voltage and current. Ex: semiconductors and gases such as neon.

V-I characteristics of fixed resistors, thermistors, and LDRs.

1. **Fixed resistors** have a linear relationship between voltage and current, meaning the current passing through them is directly proportional to the voltage applied.
2. **Thermistors** have a non-linear relationship between voltage and current, where the resistance decreases as temperature increases.
3. **Light Dependent Resistors (LDRs)** also have a non-linear relationship between voltage and current. Their resistance decreases with increasing light intensity, but the rate of change is not constant and varies with the type of LDR.



Electricity in the home

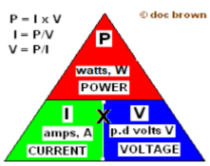
A.C. and D.C. sources.

- Examples of AC sources include generators, power plants, and outlets that provide electricity to homes and businesses.
- Examples of DC sources include batteries and solar cells.

Outline the meaning of "frequency" in relation to A.C.

Frequency in AC refers to the number of cycles or reversals in the direction of the current per second. It is measured in Hertz (Hz).

Formulas **P=I x V**



Power (chapter 9): $$P = \frac{\Delta E}{\Delta t}$$

P = power (watts, W)
E = energy (joules, J)
t = time (seconds, s)

Subtopic 8 - Electrical Safety

- Current electricity is hazardous and can cause electric shock, which can lead to ingury. Electrical arcs can cause burns, fires, and explosions, which can result in severe injury or death.
- **Short-circuiting** is a common electrical problem that occurs when a low-resistance path is created between two points in an electrical circuit.

Dangers

1. **Electrical fires**: Short circuits generate a lot of heat due to the unrestricted flow of current. This can cause electrical components to overheat and ignite, leading to electrical fires.
2. **Damage to electrical components:** When a short circuit occurs, the electrical current flowing through the circuit can exceed the design specifications of electrical components. This can cause them to become damaged or destroyed.
3. **Electrical shock**: Short circuits can also create an electrical shock hazard, particularly if they occur in a high-voltage circuit. This can be dangerous or even fatal to people who come into contact with the current.

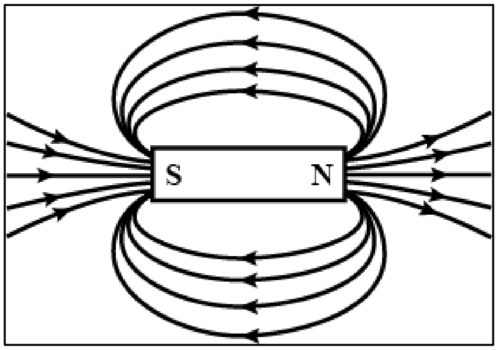
Safety features of a household plug.

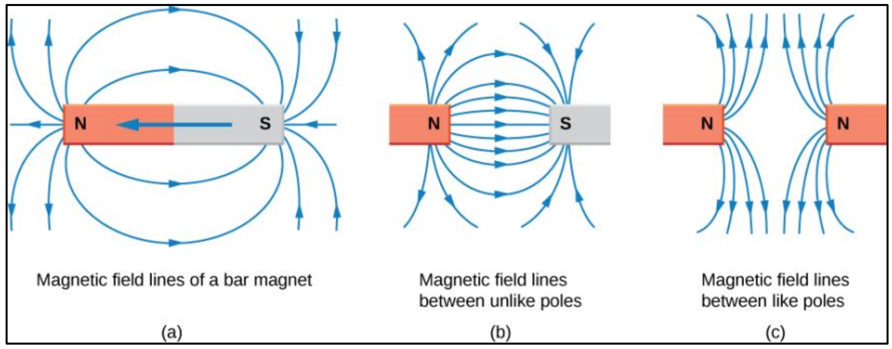
A household plug is designed with several safety features. The plug has insulation to prevent electric shock, grounding to divert electrical faults, and a fuse or circuit breaker to prevent overheating. The fuse or circuit breaker interrupts the circuit if the current exceeds a safe level. Grounding provides a path for electrical faults to flow safely into the ground.

Unit 10: Electromagnetism

Magnetic fields

Field pattern of a bar magnet.





How the magnetic effect of an electric current can be demonstrated.

The magnetic effect of an electric current can be shown by placing a compass near a wire carrying a current. The needle will change direction due to the magnetic field generated by the current in the wire.

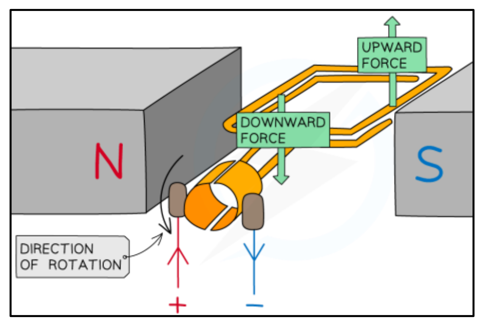
Investigate the factors that affect it's strength.

The strength of the electromagnet can be varied by changing the number of wire turns, increasing the current, or using a stronger core material.

Electromagnetic interactions (The Motor Effect)

The Motor Effect

The motor effect is the phenomenon where a current-carrying conductor placed in a magnetic field experiences a force perpendicular to both the direction of the current and the direction of the magnetic field



Factors that affect the size of the force on a conductor in a magnetic field.

1. **The strength of the magnetic field**: the stronger the magnetic field, the greater the force.
2. **The length of the conductor in the magnetic field:** the longer the conductor, the greater the force.
3. The angle between the magnetic field and the conductor: the force is greatest when the conductor is perpendicular to the magnetic field.
4. **The amount of current flowing through the conductor:** the greater the current, the greater the force.
5. **The direction of the current flow:** the force on a conductor depends on the direction of the current flow relative to the direction of the magnetic field.

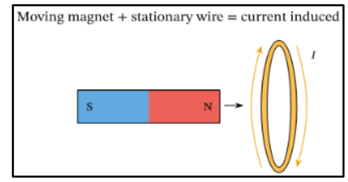
Solve problems using the formula F = BIL

$$F = B \times I \times l$$

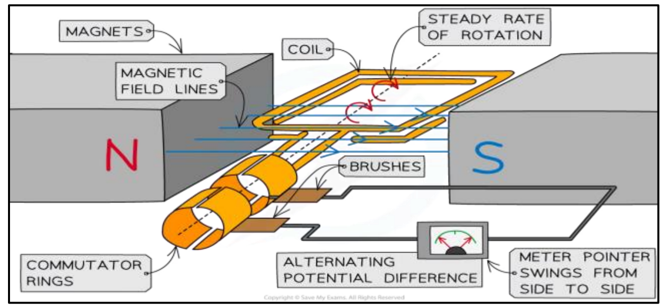
Name of quantity	Symbol when used in calculations	Unit	Symbol for unit
Force	F	newton	N
Magnetic flux density	B	tesla	T
Current	I	amperes (amps)	A
Length	l	metres	m

Electromagnetic Induction (The Generator Effect)

- A voltage is induced in a conducting wire when it moves relative to a magnetic field or when the wire experiences a changing magnetic field.
- This is known as electromagnetic induction, and the induced voltage can be used to generate electricity in devices such as generators and alternators.



How an AC generator produces an alternating current.
As one side of the coil moves up through the magnetic field, a current is induced in one direction. As the rotation continues and that side of the coil moves down, the induced current reverses direction. This means that the generator produces a current that is constantly changing.



Distributing Electricity

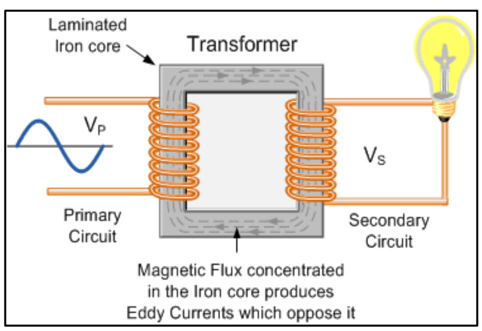
- Energy is wasted in the generation and transmission of electricity due to inefficiencies in power plants, resistance in power lines, and electrical losses during transmission, distribution, and conversion.

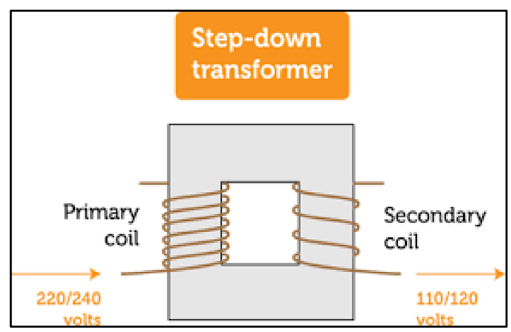
Explain how a transformer works.
It consists of two coils of wire, the primary and secondary, wrapped around a magnetic core. When an alternating current (AC) flows through the primary coil. The voltage given to the secondary coil is proportional to the ratio of the number of turns in the primary and secondary coils. By adjusting the number of turns in each loop, transformers can step up or step down the voltage of an AC power supply.

The transformer formula

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

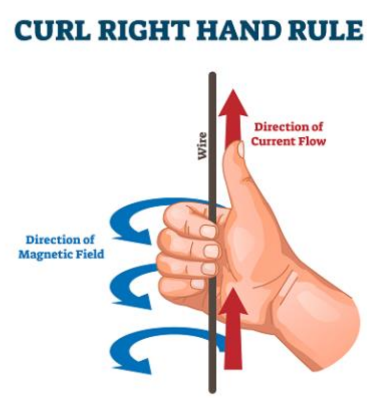
V_s = Secondary Voltage
V_p = Primary Voltage
N_s = Number of windings in secondary coil
N_p = Number of windings in primary coil



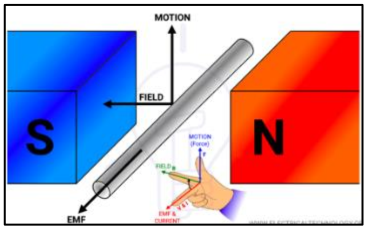


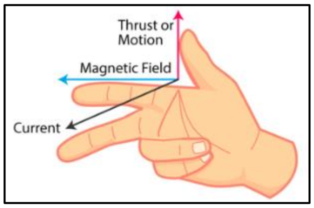
Explain why transformers are needed to distribute electricity to people's homes.
Transformers are needed to distribute electricity to people's homes because they increase or decrease the voltage of the electrical energy, making it safe and efficient to transmit over long distances. They also are used to either scale up voltage or scale down the voltage.

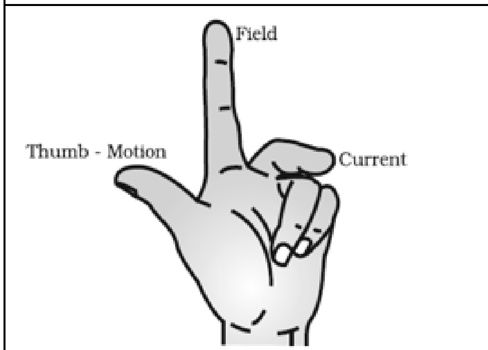
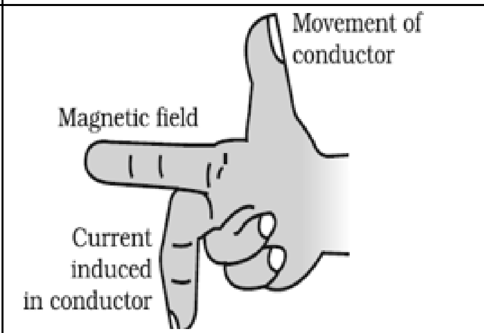
Flemings RHR
If the forefinger points in the direction of the magnetic field, the thumb in the direction of motion of the conductor, then the central finger points in the direction of the current induced in the conductor.



Fleming's LHF

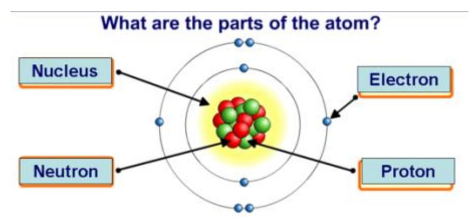




Fleming’s Left-Hand Rule	Fleming’s Right-Hand Rule
This rule is used to determine the direction of magnetic force.	This rule is used to determine the direction of induced electric current.
Centre finger/ middle finger signifies for electric current.	Centre finger/ middle finger signifies induced or generated current within the conductor.
Thumb signifies the direction of the magnetic force.	Thumb points in the direction of the motion of conductor.
Application: The direction of the magnetic field inside the solenoid is determined by Right-hand thumb rule.	**Application:** The direction of induced current within an electric generator is determined by Fleming's right-hand rule
	

Unit 11: Radiation

Atoms and Isotopes



Electrons: Negative charge; atom’s orbital shells
Protons: Positive charge; atom’s nucleus
Neutrons: Neutral charge; atom’s nucleus

Isotope: Variations of a chemical element that has same number of protons and electrons but different number of neutrons. When an isotope is unstable it is radioactive

1. **Decay series:** Process of an atom’s unstable nucleus losing energy by emitting radiation to regain stability; isotopes undergoing this are called radioisotopes.
2. **Parent isotope:** Isotope that undergoes radioactive decay, forming a daughter isotope; has an unstable nucleus.
3. **Daughter isotope**: Remaining product after a parent isotope undergoes radioactive decay; has a stable nucleus
4. **Half-life:** Measurement for radioactive decay; time is taken for a substance to become half its mass via radioactive decay. Measured in Becquerel (Bq) and that 1 Bq = 1 decay per second.

Atomic Number and Mass

1. **The atomic number**= is the number of protons + (if the atom is neutral) the number of electrons.
2. **Atomic mass:** Neutrons + Protons
3. **Number of neutrons**= atomic mass - number of protons.

Ions are electrically charged particles caused by either removing electrons from a neutral atom to give a positive ion or adding electrons to a neutral atom to give a negative ion.

Radioactivity

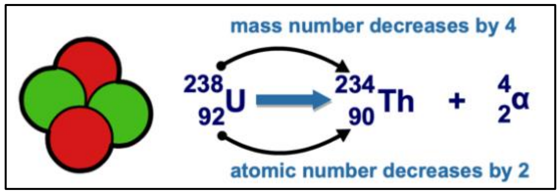
5. An unstable nucleus (all the radioactive elements like uranium has very unstable nucleus because of other elements being present) so it becomes more stable alpha or beta particle or by emitting gamma rays.
6. All unstable nuclei are trying to become more stable by emitting excess particles hence that it is a natural process and random.
7. Can be using a Geiger-Muller tube. The count rate from the sample is measured as it is proportional to the activity of the source as long as the distance between the tube and the source stays the same.
8. **Natural**: Sun's UV rays **Artificial**: X-rays

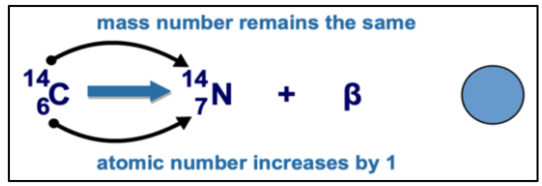
How atoms become ionized.

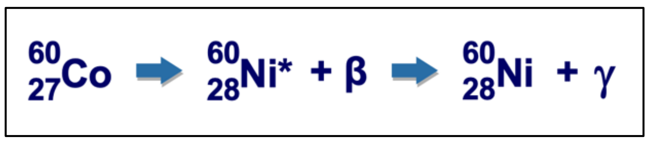
Ionizing radiation is radiation with enough energy that to remove tightly bound electrons from the orbit of an atom, causing that atom to become charged or ionized

	ionizing power	penetrating power	range in air
alpha	strongly ionizing	weakly penetrating	a few centimetres
beta	weakly ionizing	averagely penetrating	several metres
gamma	very weakly ionizing	strongly penetrating	many metres

Gamma= wave







Danger of Radioactivity

9. Gamma rays can cause cancer at high exposure but it is also used to kill cancer. Alpha rays are very harmful to the human body unlike gamma but it is used for x-rays and it has a very strong penetrating power
10. There are many dangers of radiation exposure such as Loss of hair fall, Heart and Brain issues, Thyroid problems, Reproductive system issues and cancer late in life.

    1. **Contamination** occurs when there is direct contact with radioactive substances
    2. **Irradiation occurs** when there is indirect exposure to radioactive substances.

Evaluate the selection of a particular type of radiation based on a given situation.

11. Alpha is very harmful to the human body unlike gamma as it is used for x-rays and has a very strong penetrating power
12. Gamma rays can be dangerous can break bonds and in low doses can alter DNA and can alter the DNA in the cell and can alter the metabolic rate. It can cause cancer in high exposure, but it is also used to kill cancer to.

Unit 12: Solar System

Planetary Motion

The orbital speed of a celestial body depends on its distance from the Sun and the mass of the Sun. The formula for calculating the orbital speed of a body in a circular orbit around the Sun is: $v = \sqrt{(GM/r)}$

Where v is the orbital speed, G is the gravitational constant, M is the mass of the Sun, and r is the distance between the Sun and the body.
M= 1.989 × 10^30 kg
G= 6.6743 × 10-11 m3 kg-1 s-2

Planetary orbits in terms of centripetal force and gravitational attraction

Planetary orbits are maintained by the balance between the centripetal force and the gravitational attraction between a planet and the star it orbits. The centripetal force is the force that keeps the planet moving in a circular orbit around the star, and it is provided by the gravitational attraction between the two bodies.

The strength of the gravitational force between the planet and the star depends on their masses and the distance between them. As the planet orbits, the distance between the two bodies changes, which in turn affects the strength of the gravitational force. The planet must move at the right speed and distance from the star to maintain a stable orbit.

Describe Kepler's laws for planetary motion

1. **The Law of Orbits:** Each planet moves around the sun in an elliptical orbit, with the sun at one of the foci of the ellipse.
2. **The Law of Areas:** A line that connects a planet to the sun sweeps out equal areas in equal intervals of time. This means that a planet moves faster when it is closer to the sun and slower when it is farther away.
3. **The Law of Periods:** The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit. This means that the farther a planet is from the sun, the longer its orbital period will be.

Outline Newton's law of universal gravitation

Newton's law of universal gravitation states that every object in the universe attracts every other object with a force that is directly proportional to their masses and inversely proportional to the distance between them squared.

$$F = \frac{GMm}{r^2}$$

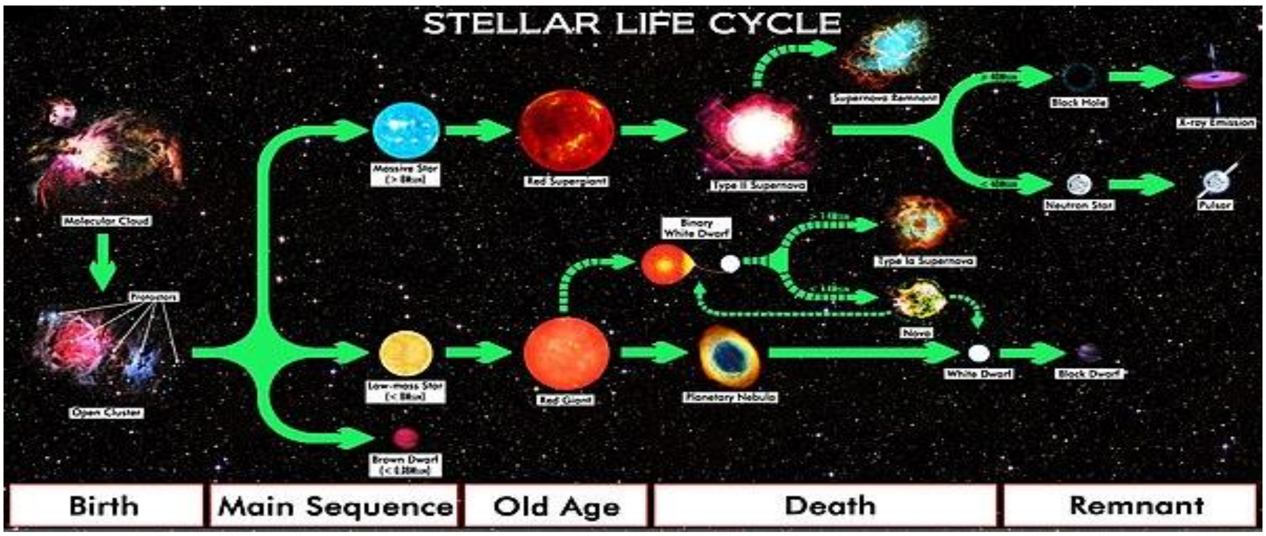
F = force of gravity
G = gravitational constant (6.67×10^{-11})
M = mass of one object
m = mass of other object
r = distance between the two objects

Calculate gravitational forces and gravitational field strengths at different positions

The gravitational force between two objects depends on their masses and the distance between them. The formula for calculating the gravitational force is:

Life cycle of a star

1. **Protostar:** This stage lasts around 100,000 years, during which a collapsing cloud of gas and dust forms a hot, dense core that will become a star.
2. **Main-sequence star:** This stage lasts for millions to billions of years, during which the star fuses hydrogen into helium at its core, releasing energy that causes it to shine.
3. **Red giant**: This stage lasts for millions of years, during which a main-sequence star runs out of hydrogen fuel and expands to become a large, cool, and luminous star.
4. **Planetary nebula:** This stage lasts for tens of thousands of years, during which a red giant sheds its outer layers and forms a glowing shell of gas and dust.
5. **White dwarf:** This stage lasts for billions of years, during which a low-mass star that has exhausted its nuclear fuel becomes a small, hot, and dense white dwarf.
6. **Black dwarf:** This stage is purely theoretical and is thought to occur after a white dwarf has cooled completely, which could take trillions of years.



Expanding Universe

13. It takes approximately 31.6 years for light to travel one light-year.
14. An astronomical unit (AU) is the average distance between the Earth and the Sun, which is approximately 149.6 million kilometers.
15. A light-year is a distance that light travels in one year in a vacuum, which is 9.46 trillion kilometers

1. **Geocentric:** Model of universe where earth is center
2. **Heliocentric:** Model where sun is the center

Big Bang: Initially all matter was in 1 concentrated point. Exploded and then expanded outwards.