Effects of Electric Current & Electromagnetic Induction (Unit 1,2,3)

Effects of Electric Current

Heating Effect	Lighting Effect	Mechanical effect	Chemical Effect	Magnetic Effect
Electrical energy is converted to Heat energy	Electrical energy is converted to Light Energy	Electrical energy is converted to Mechanical Energy.	Electrical energy is converted to Chemical Energy.	Electrical energy is converted to Magnetic Energy
• Electric Heater. • Electric Iron • Soldering Iron • Immersion Heater.	• Incandescent lamp • Discharge lamp • LED lamp	• Electric motor • Mixie • Electric Fan	• Storage battery (charging)	• Electro magnet

Heating Effect of Electric Current.

➔ **Joule Heating or Ohmic Heating.** - The process by which heat is developed in a circuit on passing current through it is known as the **Joule Heating or Ohmic Heating.**

Factors influencing the heat (H) developed, when current passes through a conductor -	• Resistance of the conductor (R)	• When the resistance (R) is increasing, current (I) is decreasing and heat is also decreasing. • If current (I) is a constant, then the heat is increasing with the increase in resistance(R).
	• Intensity of Electric Current (Current) (I)	• When current (I) increases heat also increases.
	• Time of flow of Current (t)	• When time (t) increases, heat also increases.

➔ **Electric Power (P)** – The amount of energy consumed by an electrical appliance in unit time is its **power.** (P = W/t)

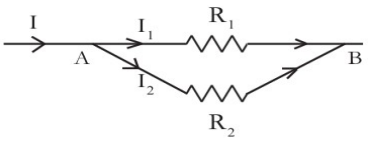
Unit of power – Watt **(W)**

• Factors influencing the **power** of an electrical device -	• Resistance(R)	• When resistance increases, power decreases.
	• Voltage (V)	• When voltage increases, power is also increases. (When the voltage is doubled, power becomes four times and when the voltage is halved power is reduced to 1/4).

Equations to calculate Heat and Power

Heat (H)	Power (P)
◆ $H = I^2Rt$ ◆ $H = VIt$ ◆ $H = V^2t/R$ ◆ $H = Pt$	◆ $P = I^2R$ ◆ $P = VI$ ◆ $P = V^2/R$ ◆ $P = H/t$

Arrangement of Resistors in Circuits

Series Connection 	**Parallel Connection** 
• Circuit is completed by connecting the resistors one after the other.	• The current completes the circuit by getting divided into each branch.
• Effective resistance is increasing.	• Effective resistance is decreasing.
• Current is same for all resistors.	• Current is different for each resistor. (Current is divided, $I = I_1+I_2$) • More current is flowing through the resistor with low resistance and less current is flowing through the resistor having high resistance. ($I_1 = V/R_1$, $I_2=V/R_2$)
• Voltage is different for each resistor (Supply voltage is divided $V = V_1+V_2$) • Resistors having high resistance gets more voltage and low resistance gets less voltage. ($V_1 = IR_1$, $V_2=IR_2$)	• Voltage is same for all resistors. (Supply voltage (V))
• Effective resistance, $R = R_1+R_2$ • If resistors of the same value are connected, **R = r X n**, (r = Value of one resistor, n = Number of resistors)	• $1/R = 1/R_1 +1/ R_2$ • Effective resistance, $R = R_1R_2 / (R_1+R_2)$ • If resistors of the same value are connected, **R = r / n**
• When bulbs are connected in series, bulb with less power (having more resistance) gets more voltage. So it glows with more brightness than the bulb with high power.	• When bulbs are connected in parallel, more current is flowing through the bulb with more power (having less resistance). So it glows with more brightness than the bulb with low power.
• When resistors are connected in series, the resistor having high resistance, gets more voltage and heated more.	• When resistors are connected in parallel, the resistor having low resistance, gets more current and heated more.

Safety Fuse.

Safety Fuse-	• **Safety fuse** is a device which protects us and the appliances from danger when an excess current flows through the circuit.
Effects of electric current in the safety fuse-	• Heating Effect.
Circumstances that cause high electric current in a circuit -	• Over loading. • Short circuit.
Over loading -	• A circuit is said to be overloaded if the total power of all the appliances connected to it is more than what the circuit can withstand.
Short circuit -	• If the positive and the negative terminals of a battery or the two wires from the mains come into contact without the presence of a resistance in between, they are said to be short- circuited.
Fuse wire -	• Alloy of tin and lead.
Features of Fuse wire -	• Low melting. • High conductivity.
Working of Fuse -	• When the current that flows into the circuit exceeds the permissible limit, the heat generated becomes excessive. Because of it's low melting point the fuse wire melts and break the circuit.
Precautions to be taken, while connecting a fuse wire in a circuit. -	• The ends of the fuse wire must be connected firmly at appropriate points. • The fuse wire should not project out of the carrier base. • Use fuse wire of appropriate amperage. • Fuse wire is connected in series.

Lighting effect of electric current

Incandescent lamps 	• In normal voltages, the filament becomes white hot and gives out light. Such bulbs are the incandescent (glowing with heat) lamps.
Filament -	• Tungsten.
Properties of Tungsten-	• High resistivity. • High melting point. • high ductility. • ability to emit white light in the white hot condition.
Bulb is evacuated -	• To avoid oxidation of tungsten filament.
Bulb is filled with inert gas or nitrogen at low pressure -	• To reduce the vaporisation of the filament.

Drawback -	• A major part of the electrical energy supplied to an incandescent lamp is lost as heat. Hence the efficiency of these devices is less.

Discharge lamps -	Discharge lamps are glass tubes fitted with two electrodes • Sodium vapour lamp • Arc lamp • Fluorescent lamp • C F L 
Light is produced in discharge lamps by the -	• Discharge of electricity through the gases filled in tubes
Working -	• When a high potential difference is applied the gas molecules get excited. Excited atoms come back to their original states for attaining stability. During this process the energy stored in them will be radiated as light • Depending on the difference in the energy levels lights of different colours and other radiations are emitted.
Advantage -	• Energy loss in the form of heat will be less.
Drawback -	• Substance like mercury in it is harmful to the environment..

LED (Light emitting diode) Bulbs-	
Advantages -	• As there is no filament, there is no loss of energy in the form of heat. • Since there is no mercury in it, it is not harmful to environment. • Low power consumption. • high efficiency. • high longevity.
<u>Parts of LED bulb</u>	
Base unit E22 -	• Metallic part that connects the bulb to the holder.
Heat sink -	• For absorbing heat.
Base plate -	• Printed circuit board is fixed in it.
Back conductor Screws -	• Screws for fixing wires from LED drive to the base unit.
Power Supply board (LED driver)	• To convert AC into DC and supply necessary output voltage.
Printed Circuit Board (LED Chip Board)	• LEDs are fixed on this board.

Diffuser cup -	• This is the part from which light comes out of the bulb.

Heating Coil	Filament	Fuse Wire
• Nichrome (Alloy of Nickel, Chromium and Iron)	• Tungsten.	• Alloy of Tin and lead.
• High melting point.	• High melting point.	• Low melting point
• High resistivity.	• High resistivity.	• High conductivity.
• Ability to remain in red hot condition for a long time without getting oxidised.	• Ability to emit white light in the white hot condition	• When excess current flows through, it melts and break the circuit.

Laws / Principles

Laws	Definition	Use
Joule's Law	• The heat generated (H) in a current carrying conductor is directly proportional to the product of the square of the current (I) in the conductor, the resistance of the conductor (R) and the time (t) of flow of current. (**$H \alpha I^2Rt$)**	• To calculate the heat produced in a current carrying conductor..
Right Hand Thumb Rule of James Clark Maxwell.	• Imagine you are holding a current carrying conductor with the right hand in such a way, that the thumb points in the direction of the current. The direction in which the other fingers encircle the conductor gives the direction of the magnetic field.	• To find the direction of the magnetic field formed around a current carrying conductor.
Right Hand Screw Rule of James Clark Maxwell -	• If a right hand screw is rotated in such a way that its tip advances along the direction of the current in the conductor, then the direction of rotation of the screw gives the direction of the magnetic field around the conductor.	• To find the direction of the magnetic field formed around a current carrying conductor.
Motor Principle -	• A conductor, which can move freely and which is kept in a magnetic field, experiences a force when current passes through it and it moves.	• For the working of electric motor.
Fleming's Left Hand Rule -	• Hold the forefinger, the middle finger and the thumb of the left hand in mutually perpendicular directions as shown in the figure. If the forefinger indicates the direction of the magnetic field and the middle finger, the direction of the current,	• To find the direction of motion (direction of force) of a current carrying conductor, which is placed in a magnetic field.

	then the thumb will indicate the direction of motion of the conductor.	
Fleming's right hand rule -	• Imagine a conductor moving perpendicular to a magnetic field. Stretch the forefinger, middle finger and the thumb of the right hand in mutually perpendicular directions. If the fore finger represents the direction of the magnetic field, and the thumb represents the direction of motion of the conductor, then, the middle finger represents the direction of the induced current	• To find the direction of induced current produced by electromagnetic induction.
Electromagnetic Induction -	• Whenever there is a change in the magnetic flux linked with a coil, an emf is induced in the coil.	

Electric devices.	**Main Parts**	**Working Principle**	**Energy Change**
DC motor	• Field Magnet • Armature • Split Rings • Graphite Brushes	Motor Principle	Electrical energy is converted to Mechanical Energy.
DC Generator		Electromagnetic Induction.	Mechanical energy is converted to Electrical energy.
Moving coil loudspeaker	• Field Magnet. • Voice Coil • Diaphragm. • Soft iron core.	Motor Principle	Electrical energy is converted to sound energy.
AC Generator	• Field Magnet • Armature • Slip Rings • Graphite Brushes	Electromagnetic Induction.	Mechanical energy is converted to Electrical energy.
Moving Coil Microphone	• Field Magnet. • Voice Coil • Diaphragm. • Soft iron core.	Electromagnetic Induction.	Sound energy is converted to electrical energy.

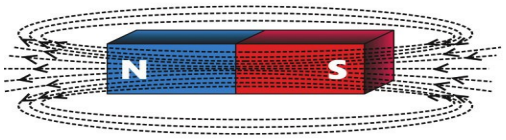
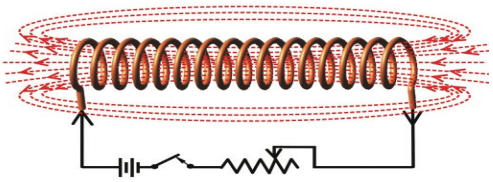
<u>Direction of magnetic field produced in a current carrying straight conductor.</u>

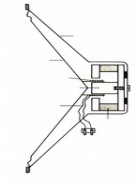
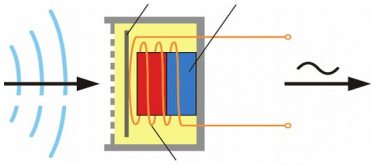
Direction of current	**Above the conductor / Below the conductor**	**Direction of motion of magnetic needle (Direction of magnetic field)**
• South to North	• Above	• West to East.
	• Below	• East to West
• North to South	• Above	• East to West
	• Below	• West to East.

Magnetic field around a current carrying circular loop

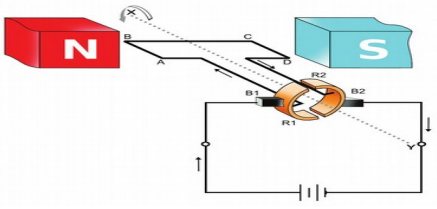
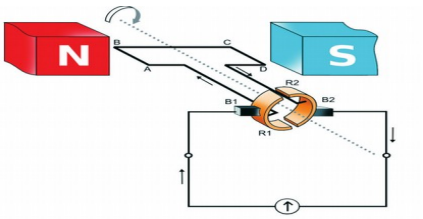
• The end of the solenoid at which current flows in the clockwise direction -	• South pole
• The end at which current flows in the anticlockwise direction-	• North Pole

• To increase the strength of the magnetic field produced in a current carrying solenoid-	• Increase the number of turns in the solenoid. • Increase the current. • Place a soft iron inside the solenoid as its core. • Increase the area of cross section of the soft iron core
• To increase the induced emf produced in a coil by electromagnetic induction-	• Increase the number of turns in the solenoid. • Increase the strength of the magnet. • Increase the speed of motion.
• Factors influencing the direction of force experienced on a current carrying conductor, when it is placed in a magnetic field -	• Direction of current. • Direction of magnetic field.
• Factors influencing the direction of induced current produced in a conductor by electromagnetic induction -	• Direction of magnetic field. • Direction of motion.

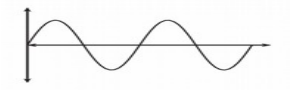
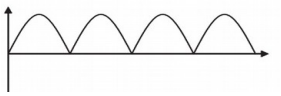
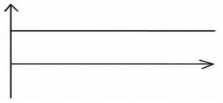
Bar magnet	**Electro magnet**
	
• The magnetism is permanent.	• The magnetism is temporary.
• Polarity cannot be changed.	• Polarity can be interchanged by reversing the current.
• Magnetic strength cannot be increased beyond a limit.	• Magnetic strength can be increased or decreased.

	Moving coil Loudspeaker	Moving Coil Microphone
		
Working Principle -	• Motor Principle.	• Electromagnetic Induction.
Energy Change -	• Electrical energy is converted to sound energy.	• Sound energy is converted to electrical energy.
Main Parts-	• Field magnet. • Voice Coil. • Diaphragm. • Soft Iron Core.	• Field magnet. • Voice Coil. • Diaphragm. • Soft Iron Core.
Working -	• The electrical pulses from a microphone are strengthened using an amplifier and sent through the voice coil of a loudspeaker. The voice coil, which is placed in the magnetic field, moves to and fro rapidly, in accordance with the electrical pulses. These movements make the diaphragm vibrate, thereby reproducing sound.	• The voice coil is situated in a magnetic field. The diaphragm connected to the voice coil vibrates in accordance with the sound waves falling on it. As a result, electrical signals corresponding to the sound waves are generated in the voice coil.

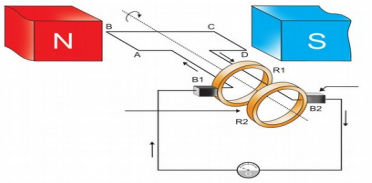
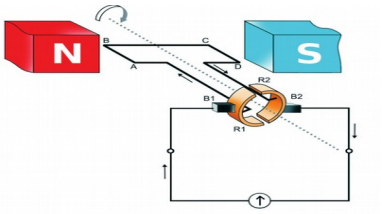
DC Motor & DC Generator

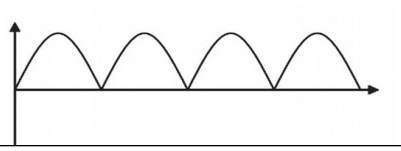
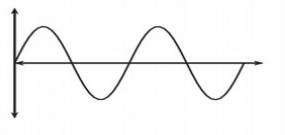
	DC Motor	DC Generator
		
Working Principle -	• Motor Principle.	• Electromagnetic Induction.
Energy Change -	• Electrical energy is converted to Mechanical Energy.	• Mechanical energy is converted to Electrical energy.
Main Parts-	• Field Magnet. • Armature. • Split Rings. • Graphite Brushes.	• Field Magnet. • Armature. • Split Rings. • Graphite Brushes.

Use of split ring commutator -	• To change the direction of current through the armature after every half rotation.	• To convert the AC produced in the armature coil to DC in the external circuit.
Working -	• When electricity is passed through the armature of an electric motor, a force is experienced on the armature and it rotates its axis based on Fleming's left hand rule.	• Rotates the armature, by using mechanical energy. Magnetic flux change is taking place, and an emf is induced on the armature coil due to electromagnetic induction. The electricity produced on the armature coil, reaches the external circuit through the slip rings and brushes

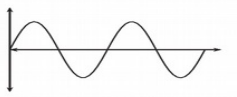
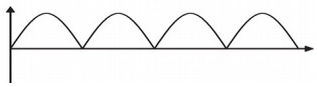
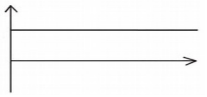
Alternating current (AC)	**Direct Current (DC)**	
• Current that changes direction at regular intervals of time, is an alternating current (AC)	• A current that flows only in one direction continuously is a direct current (DC)	
		
AC from an AC generator	From DC Generator	From Battery

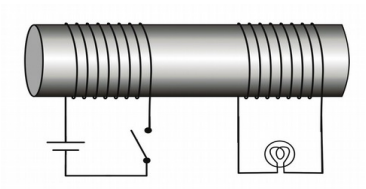
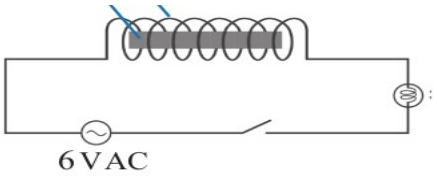
AC Generator & DC Generator

	AC Generator	**DC Generator**
		
Working Principle-	• Electromagnetic Induction.	• Electromagnetic Induction.
Energy Change -	• Mechanical energy is converted to Electrical energy..	• Mechanical energy is converted to Electrical energy.
Main Parts-	• Field Magnet. • Armature. • Slip Rings. • Graphite Brushes.	• Field Magnet. • Armature. • Split Rings. • Graphite Brushes.
Difference in structure -	• Slip rings are used instead of split rings.	• Split rings are used instead of slip rings.
Difference in the electricity produced	• AC is obtained in armature and external circuit.	• AC is obtained in armature and DC in external circuit.

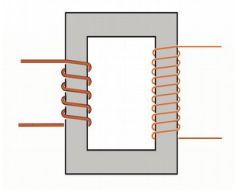
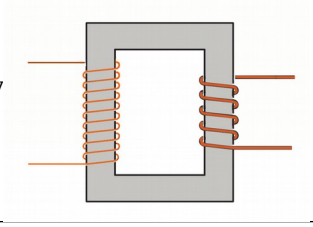
Difference in the working -	• Magnet is the rotating part (Rotor)	• Armature is the rotating part and magnet is the stationary part.
Graph of emf in the external circuit -		

Characteristics of electricity received from an AC generator, DC generator and a Battery.

• AC Generator		• Direction changes continuously. • emf increases and decreases.
• DC Generator		• ഒരേ ദിശയിൽ പ്രവഹിക്കുന്നു. • emf കൂടുകയും കുറയുകയും ചെയ്യുന്നു.
• Battery		• Direction doesn't change. • Emf increases and decreases.

Mutual induction	**Self Induction**
	
• Consider two coils of wire kept side by side. When the strength or direction of the current in one coil changes, the magnetic flux around it changes. As a result, an emf is induced in the secondary coil. This phenomenon is the **mutual induction**	• The change in magnetic flux due to the flow of an AC in a solenoid will generate a back emf in the same solenoid in a direction opposite to that applied to it. This phenomenon is known as the **self induction**
• Working principle of transformer is mutual induction.	• Working principle of inductor is self induction.

➔ **Transformer** - is a device for increasing or decreasing the voltage of an AC without any change in the electric power.

Step up transformer.	Step down transformer.
Primary  Secondary	Primary  Secondary
• Increase the AC Voltage.	• Decrease the AC Voltage.
• Number of turns in the secondary coil is more than primary coil.	• Number of turns in the secondary coil is less than primary coil.
• Thick wires are used in the primary and thin wires are used in the secondary.	• Thick wires are used in the secondary and thin wires are used in the primary.
• Output voltage (secondary) is greater than input (primary) voltage.	• Output voltage (secondary) is less than input (primary) voltage
• Output current (secondary) is less than input (primary) current.	• Output current (secondary) is greater than input (primary) current.
• Power in the primary and secondary are equal.	• Power in the primary and secondary are equal.

• Relation between the number of turns and voltages in the primary and secondary coils of a transformer -	• $V_s / V_p = N_s / N_p$
• Relation between the voltage and current in the primary and secondary coils of a transformer -	• $V_p \times I_p = V_s \times I_s$

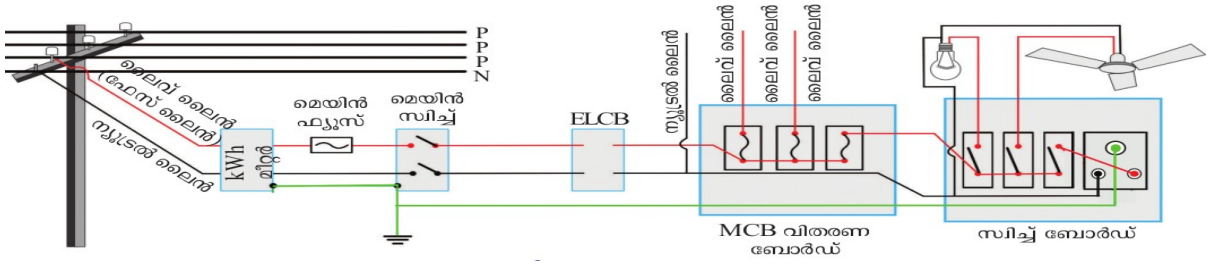
Inductor 	Resistor 
• Inductors are coils used to oppose the changes in electric current in a circuit.	• Resistors are conductors used to include a particular resistance in a circuit.
• Working principle is self induction.	• Works with the heating effect of electric current.
• Works only in AC circuits.	• Works on both AC and DC circuits.
• There is no energy loss in the form of heat.	• Energy is loss in the form of heat.

Power transmission and Distribution

• Power station -	• Places where electricity is generated on a large scale for distribution.
• Power transmission -	• It is the movement of energy from its power station to a location where it is applied to

	perform useful work.
• Transmission loss -	• When electricity is transmitted to distant places, there is loss of energy in the conductors in the form of heat.
• Major problems in power transmission -	• Voltage drop and transmission loss.
• How to reduce transmission loss -	• The voltage is increased up to 220 kV at the power station by using step up transformer. As a result the current and loss of energy in the form of heat decreases.
• Voltage of electricity produced in the power station -	• 11 KV
• Voltage at which, the power is transmitted from the power station -	• 220 KV
• Generator, used in the power station -	• Three Phase AC generator.
• Transformer, used in the power station -	• Step up transformer.
• Transformer, used in the substations -	• Step down transformer.
• Distribution transformer -	• Step down transformer.
• Input voltage of distribution transformer -	• 11 KV
• Output voltages of distribution transformer-	• Between two phases - 400 V • Between a phase and neutral - 230 V
• Voltage between phase and neutral -	• 230 V
• Voltage between neutral and earth -	• 0 V

Household Electrification



• To which device is the electric line reaching our home connected first?	• Watt -Hour Meter.
• Use of Watt -Hour Meter -	• To measure electrical energy.

• Commercial unit of electric energy -	• kilowatt hour (KWh) • 1 unit electrical energy = 1 KWh • 1 KWh = 1000 Watt hour • 1 KWh = 3600000 J
• Equation to calculate energy in kilowatt hour -	• Energy in KWh, = (Power in watt × time in hour) / 1000
• Devices are connected in the household circuit -	• Parallel method.
• Advantages of connecting devices in parallel-	• All devices gets the supply voltage. (Same voltage) • All devices gets different current. • Devices can be controlled using switches as per need. • Devices work according to the marked power. • Effective resistance is decreasing.

Safety measures in household electrification

• Safety Fuse.	• Protects us and the appliances from danger when an excess current flows through the circuit. • Works making use of heating effect of electric current.
• MCB (Miniature Circuit Breaker)	• Used in the place of a fuse wire branch circuits. • It is Automatic. • Works making use of heating and magnetic effects of electric current.
• ELCB (Earth leakage circuit breaker)	• ELCB helps to break the circuit automatically whenever there is a current leak due to insulation failure or any other reason. • Nowadays RCCB, which ensures more safety than ELCB is made use of.
• Three pin Plug and Earthing	• Ensure safety in devices having metal body.

- **Three pin Plug and Earthing**

• Which line is connected to earth pin?	• Earth Line
• Which part of the instrument is connected to the earth line?	• Metal body.
• Features of Earth wire -	• Thicker
• From where does the earth line start?	• From the Earth.
• Features of earth pin -	• Thicker and longer.
• Earth pin and earth wire are made thicker-	• To reduce the resistance in the earth circuit.

• Earth pin is made longer than other pins -	• When the three pin introduced in the socket the earth pin comes into contact with the circuit first. When the three pin is pulled out of the socket, the earth pin will be the last to break the contact. Hence complete safety is ensured.

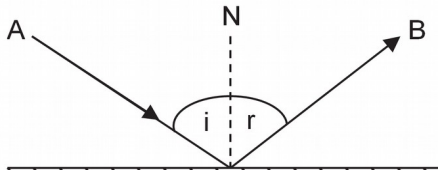
Devices working in AC	**Devices working in DC**	**Devices working in both AC and DC**
• Fan. • Motor. • Mixie. • Refrigerator • Washing Mechine	• Calculator. • Computer. • Mobile Phone. • Radio. • Television.	• Electric Iron. • Bulb.

Precautions for avoiding electric shock-	• Never handle electric equipments or operate switches when the hands are wet. • Insert plug pins into socket and withdraw them only after switching off. • Wear rubber footwear while operating electric devices. • Do not fly kites near electric lines. • Do not use table fan to dry hair.
First aid to the person, who gets electric shock-	• Raise the temperature of the body by massaging. • Give artificial respiration. • Massage the muscles and bring them to the original condition. • Start first aid for the functioning of the heart. (Apply pressure on the chest regularly) • Take the person to the nearest hospital immediately.

Phenomenon of Light (unit, 4,5,6)

Reflection of light

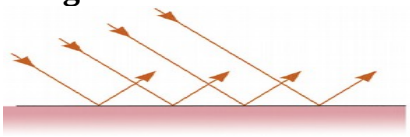
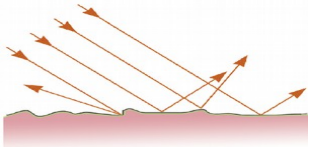
➔ Light falling on the surface of an object comes back to the same medium.



Laws of reflection

➔ Angle of incidence (i) and angle of reflection (r) are equal.

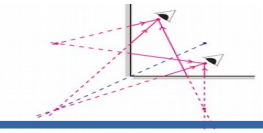
➔ The incident ray, reflected ray and normal to the surface are in the same plane.

Regular reflection	Irregular reflection
	
◆ Happens in smooth surfaces.	◆ Happens in rough surfaces.
◆ If incident rays are parallel, reflected rays are also parallel.	◆ Reflected rays are not parallel.
◆ Image is formed.	◆ Image is not formed.
◆ Angle of incidence and angle of reflection are equal.	◆ Angle of incidence and angle of reflection are equal.

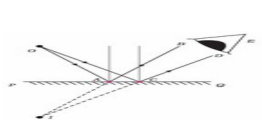
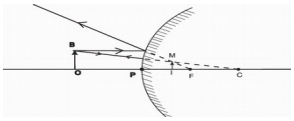
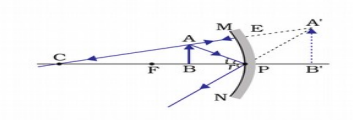
Multiple reflection and Number of images.

Number of images (n) = (360 / θ) – 1

θ = Angle between the mirror



Real Image	Virtual Image
● Image is formed on the screen.	● Image is not formed on a screen.
● Inverted image.	● Erect image.
● Formed in front of the mirror.	● Formed behind the mirror.
● Image is formed at the point on which the reflected rays are actually met.	● Image is formed at the point on which the reflected rays are appear to meet.
● Formed by concave mirror.	● Formed in convex mirror, concave mirror and plane mirror.

Plane mirror	Convex mirror	Concave mirror
		
● Reflecting surface is plane.	● Reflecting surface is curved outwards.	● Reflecting surface is curved inwards.
● The image is always virtual, erect and is of the same size as that of the object.	● The image is always virtual, erect and diminished.	● Magnified virtual image and real images of same size as that of the object, diminished and magnified are formed.
● Used for observing the face and used in the optical instruments Kaleidoscope and Periscope.	● Used as rear view mirror in vehicles and reflector in street lights.	● Used as shaving mirror, make up mirror, mirrors used by dentists. ● Used as reflector in torch, head light of vehicles, street lights and search lights. ● Used in solar concentrators and reflective telescope.

Optical density

➔ Optical density is a measure that shows how a medium influences the speed of light passing through it

➔ As the optical density of a medium increases, the speed of light through it decreases.

Increasing order of speed of light

Diamond < Glass < Water < Air

Increasing order of Optical density

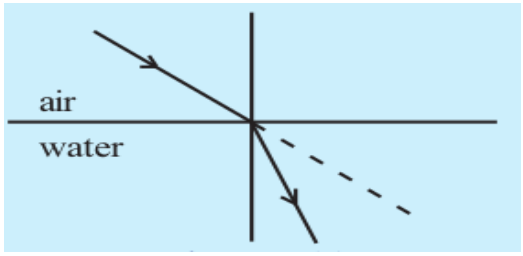
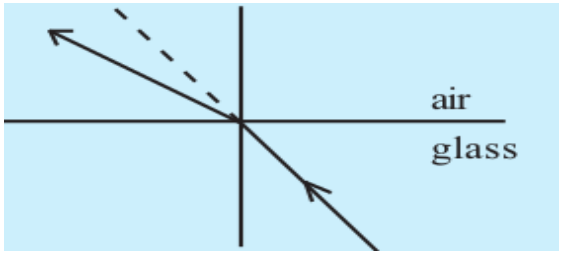
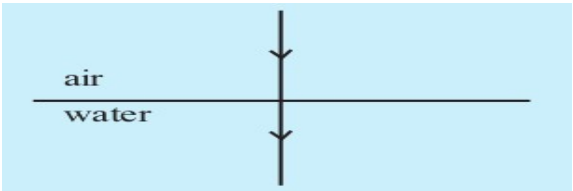
Air < Water < Glass < Diamond

Refraction of Light

➔ When a ray of light entering obliquely from one transparent medium to another, its path undergoes a deviation at the surface of separation. This is refraction.

➔ Cause of refraction – Difference in the optical densities of media

● When light is incident obliquely, from a medium of lower optical density to a medium of greater optical density,	● Refracted ray is deviated towards the normal (Angle of incidence is greater than angle of refraction)

	
● When light passes obliquely from a medium of higher optical density to a medium of lower optical density, 	● Refracted ray is deviated away from the normal (Angle of refraction is greater than angle of incidence)
● When light ray falling normally on a medium, 	● Refraction doesn't taking place.

➔ When light passes through different pairs of media, the angle of refraction increases with the angle of incidence

<u>Laws of Refraction</u>

➔ The angle of incidence, the angle of refraction and the normal at the point of incidence on the surface of separation of the two media will always be in the same plane.

➔ The ratio of the sine of the angle of incidence to the sine of the angle of refraction (sine i / sine r) will always be a constant (Refractive index) - Snell's Law

<u>Relative refractive index</u>- The refractive index of one medium with respect to another is called relative refractive index.

<u>Absolute refractive index(n)</u> – The refractive index of a medium with respect to vacuum is called absolute refractive index.

absolute refractive index (n) = sin i / sin r or $n = c/v$

c = speed of light in air/ vacuum ($3 X10^8$ m/s)

v = speed of light in medium

- Refractive index of a medium, having high speed of light (low optical density), will be low.
- Refractive index of a medium, having low speed of light (high optical density), will be high.

Increasing order of refractive index

Air (1) < water (1.33) < Glass (1.5) < Diamond (2.4)

◆ Increasing order of speed of light.	◆ Diamond < Glass < Water < Air
◆ Increasing order of optical density.	◆ Air < Water < Glass < Diamond
◆ Increasing order of refractive index.	◆ Air (1) < Water (1.33) < Glass(1.5) < Diamond(2.4)

Critical angle.

➔ When a ray of light passes from a medium of greater optical density to that of lower optical density, the angle of incidence at which the angle of refraction becomes 90^0 is the **critical angle**. The critical angle in water is 48.6^0.

Total internal reflection.

➔ When a ray of light passes from a medium of higher optical density to a medium of lower optical density at an angle of incidence greater than the critical angle, the ray is reflected back to the same medium without undergoing refraction. This phenomenon is known as total internal reflection.

Practical applications of total internal reflection in our day to day life

➔ Medical field → **Endoscope.**

➔ In the field of telecommunications → **Optical fibre cables.**

Lens

A lens is a transparent medium having spherical surfaces.

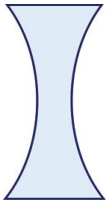
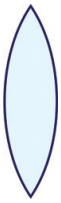
➔ **Optic centre** is the midpoint of a lens (P).

➔ **Centre of curvature** (C) is the centre of the imaginary spheres of which the sides of the lens are parts.

➔ **Principal axis** is the imaginary line that passes through the optic centre joining the two centres of curvature.

➔ Light rays incident parallel and close to the principal axis after refraction converges to a point on the principal axis of a convex lens. This point is the **principal focus of a convex lens.**

➔ Light rays incident parallel and close to the principal axis diverge from one another after refraction. These rays appear to originate from a point on the same side. This point is the **principal focus of a concave lens.**

Concave lens 	Convex lens 
◆ Thinner at its centre, than at its edges.	◆ Thicker at its centre, than at its edges.
◆ Image is always virtual, erect and diminished.	◆ Magnified virtual image and real images of same size as that of the object, diminished and magnified are formed.
◆ Image is always formed at the same side of the object.	◆ Virtual image is formed at the same side of the object and real images are formed on the other side of the lens.
◆ Image is formed at the point on which the refracted rays are appear to meet.	◆ Real image is formed at the point on which the refracted rays are actually met and virtual image is formed at the point on which the refracted rays are appear to meet.
◆ Virtual focus.	◆ Real focus.
◆ Used for resolving the eye defect myopia (Near-sightedness)	◆ Used in microscope, telescope, projector, camera, telescope etc. ◆ Used as magnifying glass. ◆ Used for resolving the eye defects hypermetropia (Long-sightedness) and presbyopia.

Images formed by a Concave mirror and a Convex Lens - Comparison

Concave mirror		Convex Lens		Features of the image.
Position of the object	**Position of the image**	**Position of the object**	**Position of the image**	
Infinity	At F	Infinity	At F on the other side of the lens.	Real, inverted, diminished.
Beyond C	Between C and F	Beyond 2 F	Between 2F and F on the other side of the lens.	Real, inverted, diminished.
At C	At C	At 2F	At 2F on the other side of the lens.	Real, inverted, same size as that of the object.
Between C and F	Beyond C	Between 2F and F	Beyond 2 F on the other side of the lens.	Real, inverted, magnified.
At F	Infinity	At F	Infinity	Real, inverted, magnified.
Between F and mirror (P)	Behind the mirror	Between F and lens (O)	At the same side of the object.	Virtual, erect, magnified.

Ray diagrams of image formation by a convex lens

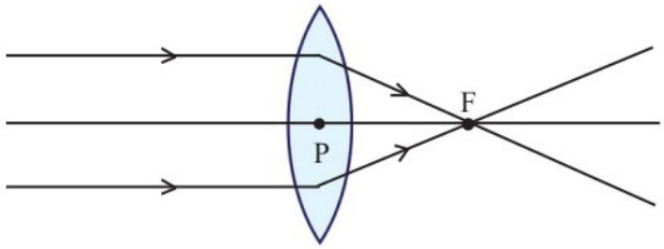
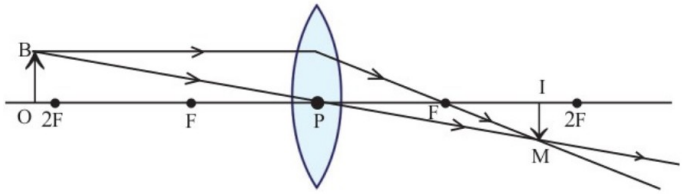
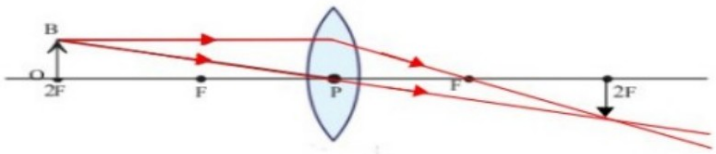
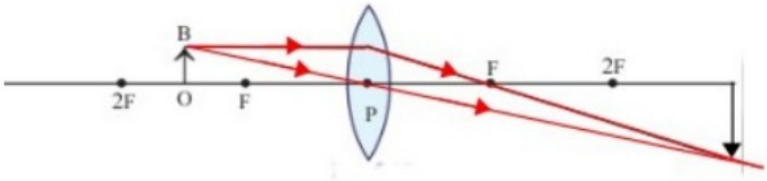
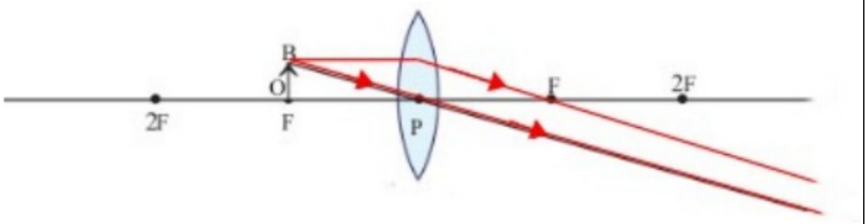
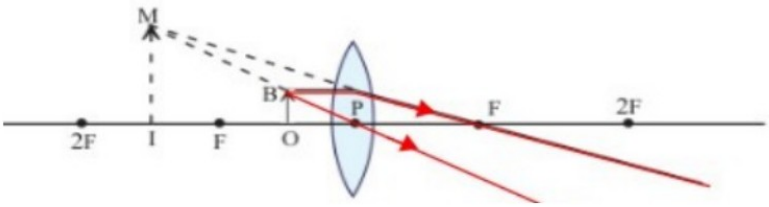
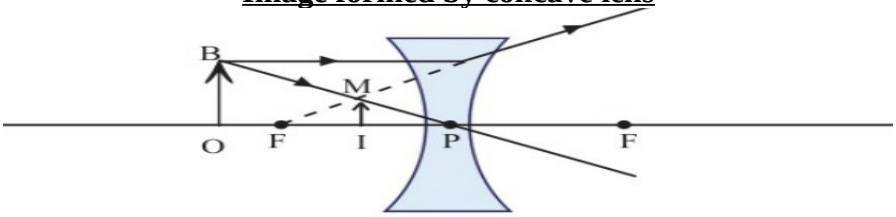
Object is at infinity	
Object is beyond 2F	
Object is at 2F	
Object is between 2F and F	
Object is at F	
Object is between F and lens.	

Image formed by concave lens



New Cartesian Sign Convention

Mirror	Lens
● Pole of the mirror is considered as the origin (O).	● Optic centre is considered as the origin (O).
● All distances are measured from the origin.	● All distances are measured from the origin.
● The incident ray is to be considered as travelling from left to right.	● The incident ray is to be considered as travelling from left to right.
● Those measured to the right from O are positive and those in the opposite direction are negative.	● Those measured to the right from O are positive and those in the opposite direction are negative.
● Distances measured upwards from X axis are positive and those downwards are negative.	● Distances measured upwards from X axis are positive and those downwards are negative..

	Plane mirror	**Convex mirror**	**Concave mirror**	**Convex lens**	**Concave lens**
Distance to the object (u)	Negative	Negative	Negative	Negative	Negative
Distance to the image (v)	Positive	Positive	Real image – Negative Virtual image- Positive	Real image – Positive Virtual image- Negative	Negative
Focal length (f)		Positive	Negative	Positive	Negative
Height of object (ho)	Positive	Positive	Positive	Positive	Positive
Height of image (hi)	Positive	Positive	Real image – Negative Virtual image- Positive	Real image – Negative Virtual image- Positive	Positive

Mirrors	Lenses
Mirror equation, 1/f = 1/u + 1/v	Lens equation, 1/f = 1/v - 1/u
f = uv / u+v	f = uv / u-v
v = uf / u- f	v = uf / u+f
u = vf / v-f	u = fv / f-v
magnification, m = hi / ho = - v / u	magnification, m = hi / ho = v / u

Magnification

- ➔ Magnification is the ratio of the height of the image to the height of the object. It shows how many times the image is larger than the object.
- ➔ Magnification (m) = Height of image (hi) / Height of object (ho)

◆ If magnification is negative,	◆ Image is real and inverted.
◆ If magnification is positive,	◆ Image is virtual and erect.
◆ If magnification is 1,	◆ Height of image and height of object are equal.
◆ If magnification is less than 1,	◆ Height of image is less than height of object.
◆ If magnification is greater than 1,	◆ Height of image is greater than height of object.

Mirror / Lens	Magnification
◆ Plane mirror.	◆ + 1
◆ Convex mirror.	◆ Positive, less than 1.
◆ Concave mirror.	◆ - 1, Negative (less than 1 or greater than 1), Positive (greater than 1)
◆ Convex lens.	◆ - 1, Negative (less than 1 or greater than 1), Positive (greater than 1)
◆ Concave lens.	◆ Positive, less than 1.

Power of a lens

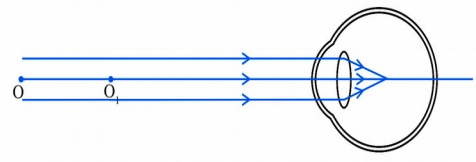
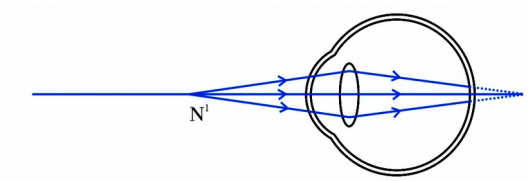
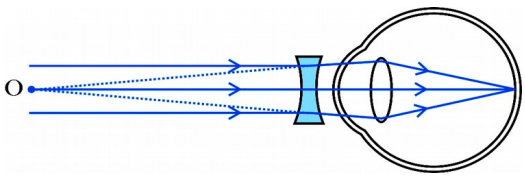
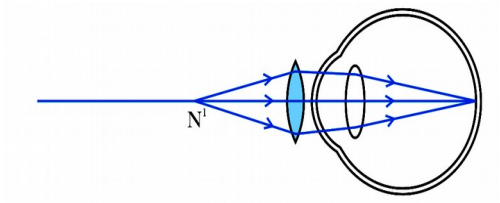
- ➔ Power of a lens is the reciprocal of focal length expressed in metres. **(p=1/f)**
- ➔ Unit of power is **dioptre**. It is represented by **D**
- ➔ Power of a Convex lens – **Positive.**
- ➔ Power of a Concave lens – **Negative**

Near point	Far point
● Nearest point at which the objects can be seen distinctly	● Farthest point at which the objects can be seen distinctly
● For healthy vision - 25 cm.	● For healthy vision - infinity

Power of accommodation.

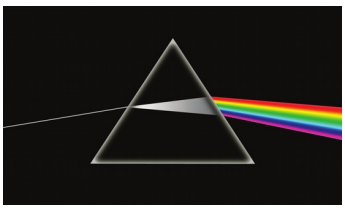
➔ The ability of the eye to form an image on the retina by adjusting the focal length of the lens in the eye, by varying the curvature of the lens, irrespective of the position of the object, is the power of accommodation.

Look at nearer objects	Looking at far objects
◆ Ciliary muscles are contracted.	◆ Ciliary muscles are relaxed.
◆ Curvature of the lens increases.	◆ Curvature of the lens decreases.
◆ Focal length decreases	◆ Focal length increases.

Myopia or Near-sightedness	Hypermetropia or Long-sightedness
	
● Can see nearby objects clearly.	● Can see distant objects clearly.
● Can’t see distant objects clearly.	● Can’t see nearby objects clearly.
● Near point is 25 cm, far point is not infinity.	● Far point is infinity, near point will be greater than 25 cm.
● Image of distant object is formed in front of the retina.	● Image of nearby object is formed behind the retina.
● Size of the eye ball may increased.	● Size of the eye ball may decreased.
● Power of the eye lens may increased. (focal length decreased).	● Power of the eye lens may decreased. (focal length increased).
● Solve this defect by using concave lens of suitable focal length. 	● Solve this defect by using convex lens of suitable focal length. 

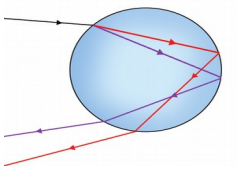
Presbyopia

- ➔ For elderly people the distance to the near point is greater than 25 cm. This defect is presbyopia.
- ➔ **Reason –** Due to the diminishing ability of the ciliary muscles, power of accommodation will be less.
- ➔ **Remedy** - Using convex lens of suitable focal length.

● Any light that is composed of more than one colour is a **composite light**	● **Dispersion** is the phenomenon of splitting up of a composite light into its constituent colours 	● The regular array of colours formed by dispersion is the **visible spectrum.**

Reason for dispersion

- ➔ Light undergoes refraction when it enters the prism obliquely and when it comes out of the prism. The extent of deviation depends on the wavelength. Therefore waves undergo deviation at different angles and get separated. This is the reason for dispersion.
- ➔ Light ray of shortest wavelength (Violet) - Deviated more.
- ➔ Light ray of longest wavelength (Red) - Deviated less.
- ➔ Order of colours from the base of the prism – Violet, Indigo, Blue, Green, Yellow, Orange, Red.

◆ Rainbow 	◆ Dispersion of light caused by the water droplets in the atmosphere causes rainbow.
	◆ Sunlight passes through the water droplets in the atmosphere **refracted twice,** and has **one internal reflection** also.
◆ Colour seen at the upper edge of the rainbow-	◆ Red
◆ Colour seen at the lower edge of the rainbow-	◆ Violet
◆ Rainbow is seen in the morning at -	◆ West.
◆ Rainbow is seen in the evening at -	◆ East.
◆ When viewing from an aeroplane rainbow is seen as a -	◆ Circle.

Persistence of vision ● When an object is viewed by a person, its image remains in the retina of the eye for a time interval of 0.0625s (1/16 s) after seeing it. This phenomenon is called **persistence of vision.**	◆ A torch rotated rapidly appears as an illuminated ◆ circle. ◆ Newton's colour disc appears white, when it rotated fast. ◆ Raindrops appears like glass rode. ◆ A fan appears like a disc, when it rotated fast.

Scattering of light ● Scattering is the change in direction brought out by the irregular and partial reflection of light when it hits the particles of the medium.	● We get light in our classrooms and homes during daytime ● Sky appears in blue colour. ● Blue colour of see.
● Colours of smallest wavelength-	● Scattered more.
● Colours of longest wavelength-	● Scattered less.
● As the size of the particle increases -	● Rate of scattering also increases.
● If the size of the particles is greater than the wavelength of light -	● scattering is same for all colours.
● Sun appears red during sunset and sunrise.	● During sunrise and sunset, light reaching us from the horizon has to travel long distances through the atmosphere. During this long journey, colours of shorter wavelength would be almost fully lost due to scattering. Then, the red light which undergoes only less amount of scattering decides the colour of the horizon
● Red colour has been given to the tail lamps of vehicles and signal lights.	● Because of its high wavelength, red can travel long distances without scattering.
● Sky appears in blue colour.	● Colours like violet, indigo and blue have the smallest wavelengths in sunlight. They undergo maximum scattering while interacting with atmosphere particles.
● Sky in moon appears in dark colour-	● There is no atmosphere in moon. So scattering of light doesn't happens in moon.

Tyndal Effect

➔ When rays of light pass through a colloidal fluid or suspension, the tiny particles get illuminated due to scattering. Because of this, the path of light is made visible. This phenomenon is Tyndal Effect

Light Pollution - The use of light in excess in a non - judicious manner is referred to as light pollution

Prepared by

Joji George, HST, St. Johns Syrian HSS Vadakara

Energy Management (Unit 7)

• Fuels -	• Fuels are substances that release plenty of heat energy on burning.
• Solid Fuels -	• Fire Wood, Coal
• Liquid Fuels -	• Petrol, Diesel, Kerosene.
• Gaseous Fuels -	• Biogas, LPG, LNG, CNG

	Complete combustion	**Partial combustion**
	• Fuels react intensively with oxygen, producing carbon dioxide, steam, heat and light.	• If sufficient oxygen is not available, the rate of combustion decreases.
Conditions favourable for the complete combustion -	• The solid fuels must be dry. • Liquid fuels must evaporate easily. • The ignition temperature should be attained. • Sufficient oxygen must be available for burning.	
Features - (Merits / Demerits)	• Carbon monoxide is not formed. • More heat is generated. • Soot is not formed. • Less smoke is produced. • Fuel loss is less.	• Carbon monoxide is formed. • Soot and smoke are formed. • Rate of combustion is less. • Atmospheric pollution. •Loss of fuel.

Fossil fuels

➔ **Fossil fuels** are formed by the transformation of plants and animals that went under the earth's crust millions of years ago. The transformation took place in **the absence of air under high pressure and high temperature.**

Fossil fuels		
Coal	**Petroleum**	**Natural gas**
• Most abundant fossil fuel on the earth. • Main component is **carbon.** • Based on the carbon content, coal is classified into four groups as **peat, lignite, anthracite and bituminous coal.** • When coal is distilled in	• Crude oil refined from the soil. • **Petrol, Diesel, Kerosene, Naphtha and LPG** are fuels obtained from the petroleum by its fractional distillation.	• Obtained along with petroleum. • **CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas)** are obtained from Natural gas. • Main component is **Methane**.

the absence of air, the substances obtained are **ammonia, coal gas, coal tar, coke.**		

L.P.G (Liquefied Petroleum Gas)	**C.N.G (Compressed Natural Gas)**	**L.N.G (Liquefied Natural Gas)**
• Obtained from petroleum.	• Obtained from Natural gas.	• Obtained from Natural gas.
• Main component is **Butane.**	• Main component is **Methane.**	• Main component is **Methane**.
• Used as fuels in Vehicles and Cooking gas.	• Used as fuels in vehicles, industries and thermal power stations.	• Used as fuels in vehicles, industries and thermal power stations.
• Transported in the liquid form. • Colourless, odourless gas. • **Ethyl mercaptan** is added as an indicator to detect gas leakage	• It is in gaseous form.	• Natural gas can be liquefied and transported to distant places conveniently.

L P G and Safety

• Expiry date of the cylinder.	• The expiry date of a cylinder is 2024 march 31, if it is marked as A24 on the top of the cylinder.
• To detect gas leakage -	• **Ethyl mercaptan** is added
• Density of LPG -	• Greater than air.
• BLEVE (Boiling Liquid Expanding Vapour Explosion)	• If there is a fire due to leakage of LPG then due to the heat the cylinder/ tanker will also get heated. Owing to the excess heat, the LPG becomes gas increasing the pressure inside. When LPG becomes gas, the container cannot accommodate the entire gas. This increases the pressure to a very high level causing a huge explosion.
• Precautions to be taken to avoid accidents due to LPG leakage -	• Examine the rubber tube at regular intervals and ensure that it does not have a leakage. • Turn on the knob of stove only after the regulator is turned on. • Ensure that the expiry date of the cylinder is not over. • If there is leakage of LPG, it is mandatory to open the doors and windows (density of LPG is greater than air) • Never switch on or switch off electricity when there is a leakage of LPG (Sparking causes fire)

• If a gas leak is suspected -	• Disconnect electricity from outside. • Switch off the regulator and shift the cylinder to an empty space. • Keep the windows and doors open. • Well trained rescue operators can put out the fire by covering the top end of the cylinder with wet sack to prevent the contact with oxygen.

Biomass	**Biogas**
• Fuels are obtained from plants and animals are known as bio-waste or biomass.	• When bio waste is deposited in a biogas plant in the absence of oxygen, biogas is formed by the action of bacteria.
• Firewood, Dried cow dung are biomass.	• Main component of biogas is c**arbon dioxide and methane.**
• The burning of bio mass will be partial combustion • Burning of it causes atmospheric pollution.	• Its calorific value is greater than biomass. • Atmospheric pollution will be less. • The slurry discharged from the biogas plant is good manure.

• Calorific value -	• The amount of heat liberated by the complete combustion of 1 kg of fuel is its **calorific value**
• Unit	• kJ/kg (kilojoule per kilogram)
• Fuel having highest calorific value -	• Hydrogen.

Hydrogen	
• Advantage -	• Calorific value is high. • Burning doesn’t causes atmospheric pollution. • Easily available.
• Disadvantages -	• Hydrogen is highly inflammable and explosive in nature. So it is difficult to store and transport it.
• Used as -	• Fuels in Rockets. • In hydrogen fuel cell to produce electricity by combining hydrogen and oxygen

• Properties of a good fuel -	• Should be easily available. • Should be of low cost. • Should have a high calorific value. • Should cause minimum atmospheric pollution on combustion. • Should be easily storable

Hydro Electric Power Station	Thermal Power Station	Nuclear power station
• Water stored at a height is allowed to flow down through a pen stock pipe. The energy of the flowing water is used to rotate the turbine and electricity is generated.	• Fuels like coal, naphtha, lignite, etc., are ignited. The heat energy thus liberated is used to convert water into steam at high temperature and pressure. The energy of steam is used to rotate the turbines to generate electricity.	• Using nuclear energy water is converted to steam at a high temperature and pressure. The force of steam is used to turn the turbines to generate electrical energy.
• Potential Energy – Kinetic Energy – Mechanical Energy – Electrical Energy	• Chemical Energy – Heat Energy - Mechanical Energy – Electrical Energy	• Nuclear Energy - Heat Energy - Mechanical Energy – Electrical Energy
• Pallivasal, Moolamattom, Kuttiadi, Sabirigiri.	• Neyveli, Kayamkulam, Ramagundam.	• Tarapur, Kalpakkam, Kota, Koodamkulam

Electrical energy from solar energy	
Solar cell -	• Converting solar energy(light energy) into electrical energy. • It is a **PN junction diode.** • Electricity is produced in it by **photo voltaic effect** (When solar energy falls on N side of a solar cell, a small electric current is obtained due to the flow of electrons to P region from N region)
Solar panel -	• Large number of solar cells are suitably assembled in it. • It is used in lighting street lamps, artificial satellites, space stations and remote forest areas.
Solar photo voltaic power plants (SPV) -	• Used solar panels in it. • The solar power plant at the International Airport in Nedumbassery is an example of SPV.
Drawback-	• Cannot be used at night and cloudy conditions. • Battery is needed for storing electricity.

<u>Heat energy from solar energy</u>	
Solar Cooker -	• Used for cooking. • The main parts are, a box with blackened interior (for absorbing heat), a glass cover for the box (for transmitting light) and a mirror outside the box (for reflecting light).
Solar Water Heater -	• Hot water required for hospitals and hotels for cooking food, and for washing vessels in houses etc., can be produced using solar water heater.
Solar Thermal Power	• Generates electricity using solar energy.

Plant -	• Concave reflectors are used to focus the sun's rays on the blackened pipes filled with water. As a result, water boils and vaporises. The steam rotates the steam turbine, so that the generator attached to the turbine is activated.

Energy from wind-	• Electricity is obtained by turning the turbine of generator using the wind power.
Advantages -	• It is renewable. • Environment friendly. • No recurring expenditure.
Limitations -	• It can be established only at those places where wind is available for most time of the year. • The expense to establish a wind mill is very high. • Require storage systems to use electricity when there is no wind.

Energy from sea	
Tidal Energy -	• During the time of high tide water is allowed to enter in to a tank and water will flows to the sea during low tide. Using the energy of this flowing water turbine is rotated and electricity is produced.
Energy from waves -	• Operate a generator by turning the turbine by using the power of sea waves.
Ocean thermal energy -	• The surface of ocean is relatively hot due to solar radiations. But the temperature will be very low at the deep levels. Ocean Thermal Energy Conversion Plants (OTEC) produce energy, making use of this difference in temperature.

Geo thermal energy -	• Magma, which is at a higher temperature, comes out of the core of the earth through its softer regions. (Hot spots) • Underground water at this place receives heat energy from the hotspot and is converted into steam. This steam, which is confined to the region between rocks, is brought out by drilling pipes through the rocks. Using this steam, turbine is rotated to produce electricity.

Energy from Nucleus	
Nuclear fission	**Nuclear fusion**
• Nuclear fission is the process by which the nuclei of greater mass are split into lighter nuclei, using neutrons.	• Nuclear fusion is the process in which lighter nuclei are combined to form heavier ones.
• According to Einstein's equation **E = mc^2**,	• According to Einstein's equation **E =**

lost mass is converted to energy.	**mc^2**, lost mass is converted to energy.
• In **nuclear reactors**, energy is produced by nuclear fission. • Uncontrolled fission will end in a huge explosion. This is the process that takes place in an **atom bomb**	• Energy is produced in stars and sun by nuclear fusion. • Nuclear fusion is the principle used for making a **hydrogen bomb.**
• Power stations to control fission reaction and produce electricity are **Nuclear power stations.** • **Nuclear reactor** is a system that converts nuclear energy into electrical energy. • **Enriched uranium and carbide** are fuels used in nuclear reactors.	• The scientific world has not yet been able to produce energy commercially by controlled nuclear fusion.

• Nuclear Pollution -	• The pollution caused by the presence of radioactive substances and radiations in water, air and environment is known as **nuclear pollution.**
• Natural nuclear hazards -	• Cosmic rays from outer space. • Radiations from radioactive materials on the Earth.
• Man made nuclear hazards -	• The use of radioactive isotopes in the medical field. • Wastes from nuclear reactors.
• Precautions to face nuclear hazards -	• Shift out to safe places (Concrete buildings, buildings constructed using bricks etc). • Strictly follow the directions from the concerned authorities. • Observe the symbols showing the nuclear radiations and behave accordingly. • Reduce the density of population in places likely to experience nuclear hazards.

Renewable Sources of energy	**Non renewable sources of energy**
• Those which replenish energy as it is being used up are the renewable sources of energy.	• These are not replenished or renewed in proportion to their consumption.
• Sun light, Wind, Geo thermal energy Tidal energy, Wave energy, Biomass, Biogas etc., are renewable sources of energy.	• Fossil fuels (Petroleum, Natural gas, Coal) and Nuclear fuels are Non renewable source.

Green Energy	**Brown Energy**
• Green energy is the energy produced from natural sources that does not cause environmental pollution.	• The energy produced from non renewable sources such as petroleum and coal, and the nuclear energy are named

	brown energy.
• Doesn’t cause environmental pollution. • Renewable source.	• Non renewable. • Cause environmental pollution. • Cause global warming.
• Solar Energy • Wind Energy. • Tidal Energy. • Geo Thermal Energy. • Bio mass. • Biogas. • Hydro Electric Power. • Hydrogen.	• Fossil fuels (Petroleum, Natural gas, Coal) • Nuclear Energy.

Energy crisis -	• **Energy crisis** is the consequence of increasing demand but decreasing availability.
Reasons for energy crisis -	• Energy is wasting. • Excess usage of non renewable sources of energy. • Industrialisation • Population growth.
Solutions for energy crisis -	• Judicious utilisation of energy. • Maximum utilisation of solar energy. • Making use of public transportation as far as possible. • Timely maintenance of machines.
Devices used at home to reduce energy consumption -	• Hot box. • Pressure cooker. • Energy efficient oven.