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NATURAL SCIENCES GRADE 8 TERM 3 NATURAL SCIENCES

STATIC ELECTRICITY : (2 Weeks)

Core concepts

- Friction and
- Static electricity

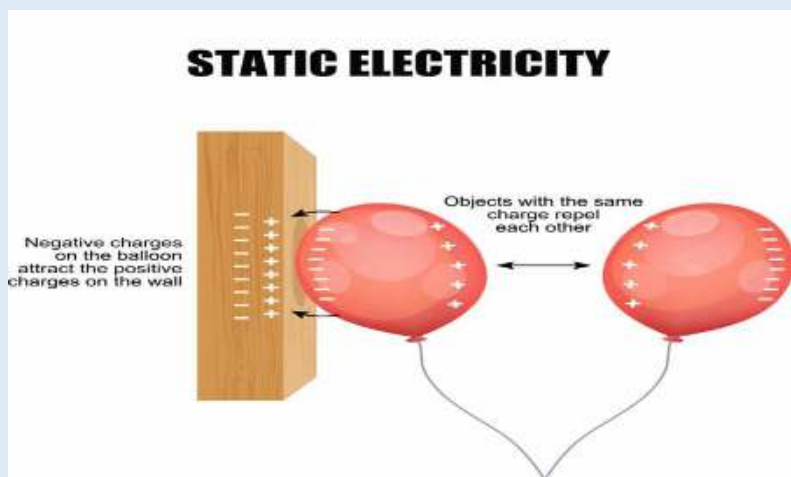
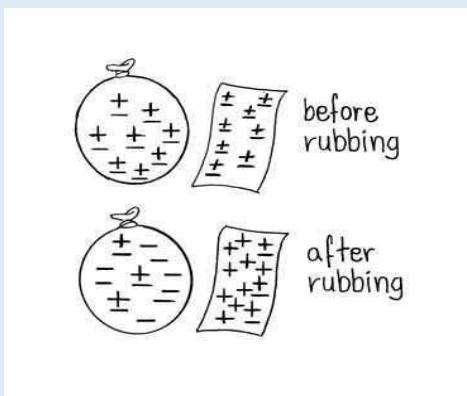
FRICTION

- **Friction:** is a *force* caused by **rubbing things together**. Friction is the force that *resists the movement between 2 objects*.
- Friction between objects causes *electrons to move from one object to another*.
 - a) The **object that gains electrons** becomes **negatively charged** because it has *more electrons than protons*.
 - b) The **object that loses electrons** becomes **positively charged** because it has *fewer electrons than protons*.
 - c) **Electrons are never created or destroyed**. The *number of electrons that the one object loses* is the same as the number of electrons that the other object gains.
- The **separation of charges** is called **Static electricity**.
- ❖ The electric charges **do not flow** like in an electric circuit. The **charges stay still or static**, hence called static electricity.

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DEMONSTRATION OF STATIC ELECTRICITY

1. **Blow up the balloon against your hair.**

- a) The balloon and hair are neutral: *equal numbers of positive (protons) and negative charges (electrons)*
 - b) When the *balloon is rubbed against hair*, there is a *force of friction between the balloon and the hair*.
 - c) The *friction causes the outer electrons of the atoms of the hair* to be transferred to the balloon.
 - d) The **hair loses electrons**, which causes a *positive charge on its surface* & **balloon gained electrons**, which caused a *negative charge on its surface*.
 - e) When you **place this charged balloon to the wall**, it will *stick to the wall* [The *charge on the balloon makes it stick to the wall*].
- ❖ **Both the hair and balloon are isolators and cannot conduct electricity.** The charges remain **static** on their surfaces.
 - The *negative build-up on the surface of the balloon remains static*.
 - **Through friction** we can **charge materials**, such as plastic, perspex, glass, nylon and wool.
 - **Static electricity:** is the separation of charges through friction.



ELECTRIC DISCHARGE

- **Static electricity:** is the *build-up of electric charges on the surface of an object*, which is usually a **non-conductor of electricity**.
- When the *build-up of charges becomes too big for the object* the **electrons will be discharged** to a *neutral or positive object*.
- **Electric discharge:** is the *release of electrons* through a solid, liquid or gas. It can **take place** during *contact between two objects* or *across a small gap of air between two objects*.
- a) A **discharge of electrons** causes the **sparks**, or *shock of static electricity*, especially when the *air is dry*. **Lightning is an example of an electric discharge**.
- When a person walks across a room with a carpet, **friction occurs** between the person's shoes and the carpet. As a result, the **person becomes positively charged** because *electrons are transferred from the person to the carpet*.
- There is a **build-up of positive charges** on the *surface of the person*. The **charge remains static**.
- When the person touches a doorknob, **electrons from the doorknob will be attracted to the positively charged person**. They will *move quickly to the hand of the person* and will **experience this flow of electrons** as an **electric shock** that can jump from the knob to the finger, giving the person a *slight shock*.
- When **electrons move across an air-gap** they can **heat the air enough to make it glow**. This glow is called a **spark**.
- Although the **sparks caused by static electricity cannot harm you** they can be *dangerous if you are near fuel* because it can *cause an explosion*

ENERGY TRANSFER IN ELECTRICAL SYSTEMS: [3 Weeks]**Core concepts**

- **Circuits and current electricity**
- **Components of a circuit**
- **Effects of an electric current**

CIRCUITS

- A **circuit**: *complete conducting pathway* along which *electric charges can move to an appliance where it does its work*.
- In a circuit, there is a *transfer of electrical energy to other forms of energy*, eg in a **light bulb**, *electrical energy is converted to light and heat energy*:
- **System**: parts that work together to make something happen **eg torch** has the battery, conducting wires, switch and light bulb that **work together to form a system** & transfers energy.
- **Cell**: chemical system that stores chemical potential energy
- **Electrons get electrical energy from the battery/ cell** & when the electrical energy reaches the light bulb, some of the electrical energy is used to heat the filament in the light bulb and make it glow.
- *Electrical energy is transferred to heat and light energy*

COMPONENTS OF A CIRCUIT

- Circuits are made up of **different components**, namely **cells** (batteries), **conducting wires**, **resistors** (bulbs) and **switches**.

THE CELLS

- A **cell**: contains **chemicals** that store energy in the *form of potential energy*.
- The *cell provides energy/ source of energy* to the electrons so that they can *move along a wire* by *producing electrical energy from the potential energy* in the chemicals.
- **Battery**: consists of **2 or more cells** that are **connected** together.
- When the **cell is connected in a circuit** the *chemicals react to produce electrical energy*.
- An **electric cell** has a *small metal cap* (positive terminal) on one side & a *metal disc on the other side* (negative terminal) of a cell.

- *Electrons move out of the negative terminal of the cell through the connecting wires and back, to enter the cell through the positive terminal.*
- *Electric cells are used in cameras, clocks, remote controls and motor cars.*
- When the **chemicals in the electric cell are used up**, the *electric cell stops producing electrical energy* and the cell is regarded to be **flat**.



CONDUCTING WIRES

- **Conductor:** material that *allows electrical energy to flow through* it easily. Metals are conductors eg copper.
- A **conducting material** is needed to provide a path for the electrons to move *from the source of energy* (cell or battery), to a **device** like a light bulb.

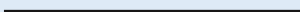
SWITCH

- **Switch:** is a device that is used to *control the flow of current* through a circuit.
- If a *switch is open*, the *circuit is broken* and *no current will flow*.
- If a *switch is closed*, the *circuit is complete* and a *current will flow*.
- We use switches to turn electrical appliances, such as fans, lights and heaters, **on and off**.
- The **mains switch in a house controls how much electrical energy flows into a house**.
- When there is a *sudden increase in electrical energy*, the *mains switch will 'trip' and break the circuit* so that a *current cannot flow*.

RESISTORS

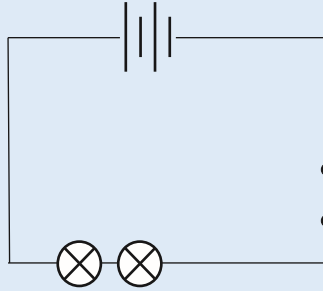
- **Resistor:** is a component of a circuit that *resists or opposes the flow of an electric current*.
- A **resistor** uses electrical energy and *change it into heat energy or light energy* eg a light bulb.
- *Good conductors have low resistance, poor conductors offer high resistance.*
- *Resistors are found in computers, televisions and telephones* where they are used to *control the flow of electrical current*.
- There are **2 types of resistors**:
 - a) **Fixed resistors** with a *fixed resistance*, and
 - b) **Variable resistors** where the *resistance can be changed*.
- A **variable resistor or rheostat** can be used to *change the resistance in a circuit*. An example is a *dimmer switch for lights* which makes the light in a room dimmer or brighter.

CIRCUIT SYMBOLS

COMPONENT	SYMBOL	FUNCTION/ PURPOSE
Cell 		Source of electrical energy
Light bulb		Converts electrical energy to light energy
Open switch		Stops the flow of electrical energy by making a break in the pathway
Wire		Gives electrical energy a path to travel along

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- A **circuit diagram**: uses *standard symbols* to represent the basic components of the circuit.
- **Conventional current**: is always indicated on the line of a conductor with an arrow **from the positive terminal** to the **negative terminal of a conductor**.
- The symbol for a cell is a **long line** that represents the **positive terminal** and the **short line** representing the **negative terminal**.
- The **conductor** is represented by an **unbroken line**. Example below:

**ELECTRICAL CURRENT**

- 1) **Electric current**: is the constant **flow/ movement of negative charges/ electrons from an energy source** along a conductor in a circuit. **It is a form of kinetic energy, because the electrons are flowing**
- 2) For the current to flow, the **circuit** must be **complete (closed switch)**.
- 3) The cell/battery has chemicals that “do work” by **pushing & moving electrons from the positive pole to the negative pole of the battery** and concentrating protons on one end of the battery.
- 4) **Without the push of the battery**, the electrons would be attracted to the protons and stay at the positive contact. **Electrons move from areas of higher concentration to areas of lower concentration**
- 5) The electrons are pushed by the electrons behind it and that **makes them all move at once and makes the bulb light.**
- 6) Inside the bulb (*there’s a filament offering resistance*) **make it difficult for electrons to move along it. This results in energy transfer that heats the filament, which becomes hot enough to glow and give off light.**
 - The **higher the voltage of the battery**, the more the battery is able to push electrons away from the protons.

- Electric current is *measured* in *ampere* (A) using an *ammeter connected in series in the circuit*.

THE HEAT EFFECT OF AN ELECTRIC CURRENT

- 1) When an *electric current flows through a conducting wire*, the *electrons give some of their electrical energy to the atoms in the wire*.
- 2) These **atoms start to vibrate more** and the *wire gets hotter*. We call this the **heating effect** of an electric current.
- 3) When an **electric charge flows through a resistor**, *electrons use more electrical energy to overcome resistance* & this energy (*electrical energy*) is **converted to heat energy** in the resistor, that can be used in a *light bulb, stove, heater and toaster*.
- 4) The **greater the current flowing**, the *hotter the resistor becomes*, because *more energy is transferred to the atoms in the resistor*.

SHORT CIRCUIT

- 1) A **short circuit** occurs when an *electric current takes the easiest path through a circuit which is a path of lowest resistance*. The *current* does not pass through the main circuit
- 2) It **occurs** when a *conductor is connected directly to both terminals of a cell* or when 2 wires are *not properly insulated and touch each other*. The current will flow from the one wire to the next wire **without completing the intended circuit**.
- 3) Short circuits are **dangerous**. When *too much current passes through a conducting wire*, it **melts** and causes the *insulation to start burning*, may cause damage to other components in the circuit, or even electrical fires.
 - **Safety precaution:** **circuits in houses and cars can be fitted with fuses** to *prevent fires* and circuits from **overheating**.
 - A **fuse**: is a *short length of metal (safety device) consisting of a special wire with high resistance and low melting point*. It protects the circuit when there is too much electric current flowing through the appliance. It breaks **the circuit** when it **overheats and melts**.



Figure 1 Fuse

- Most modern homes have **circuit breakers** which are similar to a fuse in that it is designed to protect an electric circuit from damage, **due to overload** or a short circuit, by **stopping the current flow**.

MAGNETIC EFFECT OF AN ELECTRIC CURRENT



Figure 2 Bar magnet

- A **magnet**: is a material that has a *magnetic field around it*.
- A **magnet** can *repel or attract another magnet*. Examples of magnetic materials are Iron, nickel and cobalt.
- Most magnets**, like the ones on refrigerators, *cannot be turned off*. They are called **permanent magnets** because they are **magnetic all the time**, *example is a bar magnet*
- A magnet has a **N-pole** and a **S-pole** that are indicated by a compass
- A **compass** can be used to determine the **pole of a magnet**. It *always points towards the N-pole*. A **current** causes a *circular magnetic field around it*.
- A **conductor behaves like a magnet when current flows through it**.
- When *no current flows through the conductor*, it has *no magnetic effect*. The *conductor acts as a temporary magnet*.

ELECTROMAGNET/ TEMPORARY MAGNETS

- 1) **Electromagnet:** is a *piece of metal* that *becomes a magnet* when an *insulated wire coiled around the metal carries an electric current*.
When the current is switched off, the magnetism disappears.
- 2) An electromagnet is *created and controlled by electricity*. It *only acts as a magnet when current flows through the copper wire*.
- 3) When an *electric current passes through the conductor*, the *light bulb will shine*, and the *electric current causes a magnetic field*.
 - a) This *magnetic field deflects the compass*. It means that the compass **will move** so that it *points to the N-pole* of the magnetic field.
 - b) An **electromagnet** is also *controlled by the current* that flows through the conductor.
 - c) When the **switch is on**, a *magnetic field is generated* and the **electromagnet acts as a magnet**. A *compass can be used to prove that a magnetic field surrounds the conductor*.
 - d) When the **switch is off (breaks the circuit)**, the *magnetism of the electromagnet is switched off*.
 - An electromagnet is a **temporary magnet**, because it can be *turned on and off*

USES OF ELECTROMAGNETS

- a) *Large electromagnetic cranes* are **used in scrap yards** and are *strong enough to lift heavy weights*.
- b) Used to *lock security doors in banks* and in *circuit breakers in switch boxes in homes*.

THE CHEMICAL EFFECT OF AN ELECTRIC CURRENT

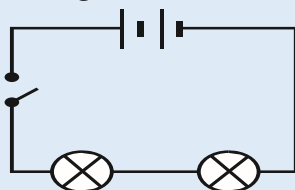
- If an *atom loses electrons* it becomes a **positively charged ion**. If an *atom gains electrons*, it becomes **negatively charged**.
- When the *salt dissolves in water*, the **positive ions and negative ions are separated**.
- An **electrolyte:** is *solution* containing **free electrons**, through which a **current can pass** through.

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- When *electricity is passed through an electrolyte*, a **chemical reaction occurs** to *create a different chemical*.
- **Electrolysis:** is the process by which *ionic substances are decomposed into simpler substances*, when an electric current is passed through them.
- **Tap water is a conductor of electricity** because it contains ions.
- The *energy conversion* that takes place during electrolysis consists of *chemical energy changing to electrical energy*.

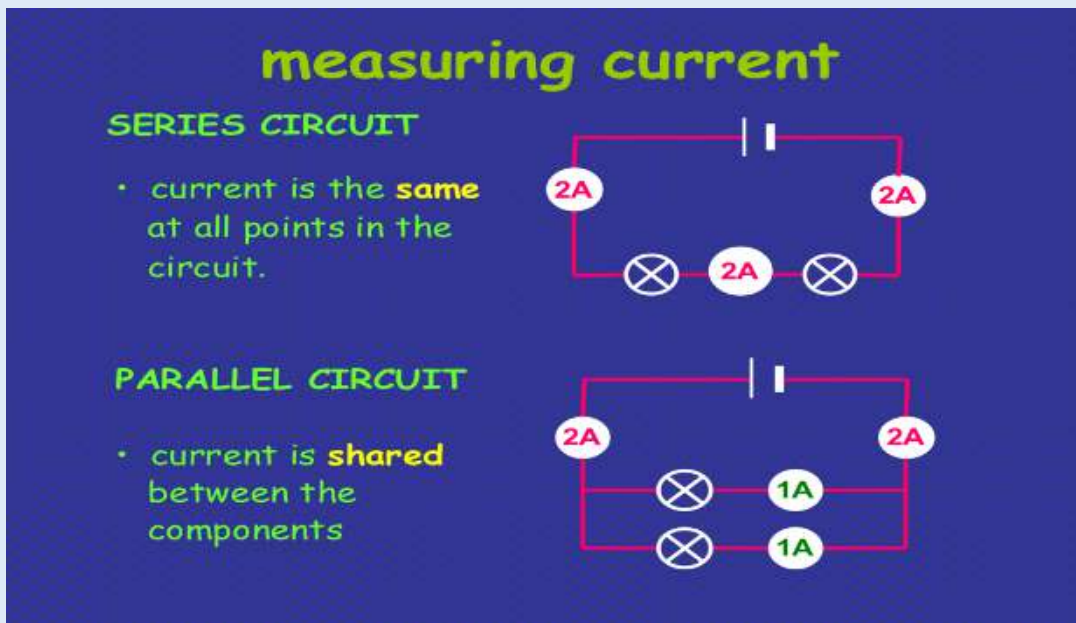
SERIES AND PARALLEL CIRCUITS [1 Week]**SERIES CIRCUIT**

- 1) A **series circuit:** is a circuit that provides *only one path* along which a current can flow.
- 2) It has 2 or more light bulbs connected in a line, or a series.
- 3) The *amount of current is the same through each part* or component in the circuit. This means that *all the light bulbs in series will shine with the same brightness*.
- 4) **Every time a resistor** (eg light bulb) is **added in series**, *opposes the flow of current* & the *overall current in the circuit decreases* and *total resistance increases*.
 - a) When *more light bulbs are added in series*, the *current has to flow through each resistor* and the *resistance to the flow of the current increases*.
 - b) If *one of the bulbs burn out*, the *circuit is broken* and the *electricity stops flowing*. *Christmas lights are often connected in series*.
 - c) An **advantage of light bulbs in series** is that *one switch switches on all the light bulbs*.



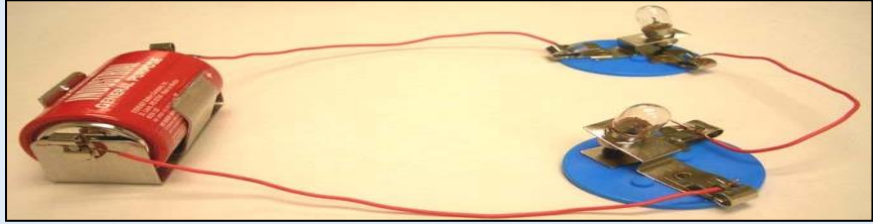
PARALLEL CIRCUITS

- 1) **Parallel circuit:** provides *2 or more pathways* for the current passing through it.
- 2) When *more resistors (bulbs) are added in parallel*, the *total resistance* of the circuit *will decrease* and the *overall current will increase*.
- 3) The *total current equals the sum of the currents* that *flow through each branch of the parallel circuit*.
- 4) There are 2/ more possible paths the current can take. When the **current re-joins**, it will have the *same strength as before the split*.
- 5) If the bulbs have a *different resistance to each other*, then *more current will flow through the branch that has the least resistance*.
The current will prefer the easier path.
- 6) **Light bulbs in houses and buildings are connected in parallel.**

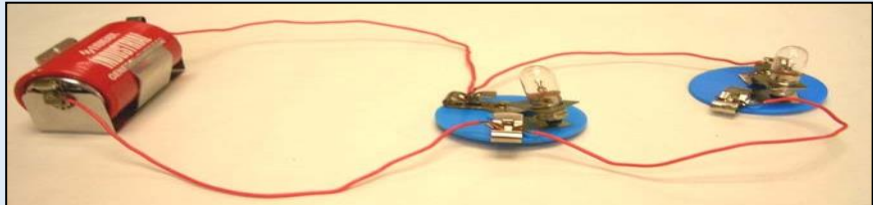


Some Configurations of Series and Parallel Circuits

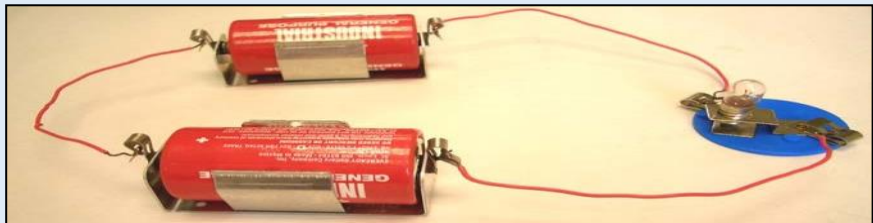
**Series Circuit
(Bulbs in series)**



**Parallel Circuit
(Bulbs in parallel)**



**Series Circuit
(Batteries in series)**



**Parallel Circuit
(Batteries in parallel)**



VISIBLE LIGHT: [3 Weeks]

Core concepts

- Radiation of light
- Spectrum of visible light
- Opaque and transparent substances
- Absorption of light
- Reflection of light
- Seeing light
- Refraction of light

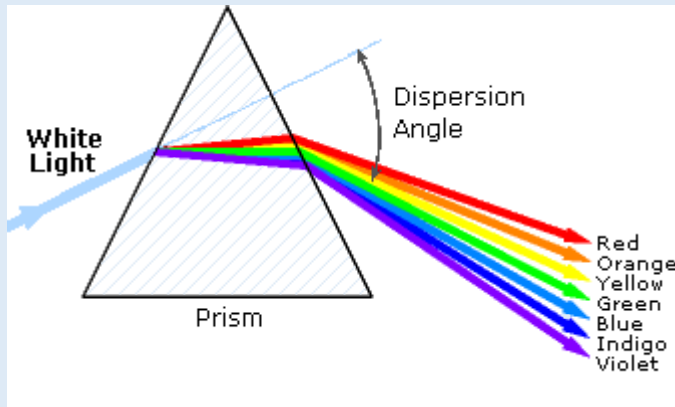
as Newton passed a narrow beam of white light a spectrum.

RADIATION OF LIGHT

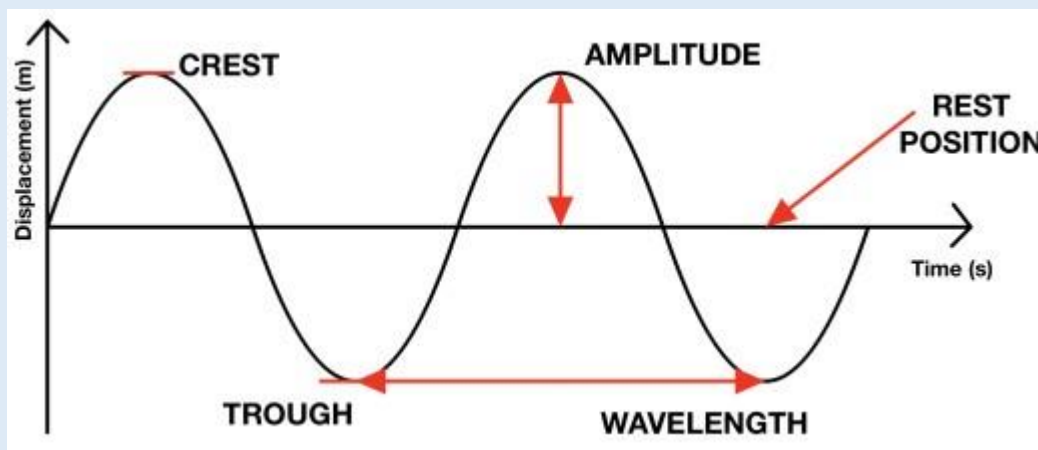
- **Luminous objects:** *radiate their own light / object that is a source of light* e.g. Sun (*Our main source of light on Earth is the Sun*) & is about 150 million km from the Earth.
- 1) Light is emitted & transferred from **luminous objects** by **radiation** & travels in *straight lines*.
 - The **shadow** of an object is *proof that light travels in straight lines* because it *cannot bend around the object*.
- 2) *Light travels very fast* in a **vacuum** at a speed of 300 000 kilometres per second ($c = 3 \times 10^8 \text{ m.s}^{-1}$).
- ❖ **Illuminated object:** *object that does not have its own light but reflects light from the light source* eg moon, because it *does not give off its own light, but reflects light from the Sun*.
- ❖ **Transparent objects:** are objects through which other objects can be seen clearly e.g. glass or Perspex.
- ❖ **Translucent objects:** are objects like frosted glass and wax paper which transmit light through which objects cannot clearly be identified
- ❖ **Opaque objects:** are objects which do not transmit light at all e.g. brick or book

SPECTRUM OF VISIBLE LIGHT

- 1) Sir Isaac Newton *passed a narrow beam of white light* through a *triangular glass prism* & he observed that *white light was “spread out” to form a spectrum*.
- 2) When *white light travels through a triangular prism*, it *separates* into a *number of 7 different colours namely red, orange, yellow, green, blue, indigo & violet*. This phenomenon is called **dispersion** and **refraction**.



- a) **Red light is refracted the most** and **violet light is refracted the least**.
- b) A rainbow is seen when **white light is dispersed** and **refracted by water droplets** in the **air into the different colours** of the spectrum.
 - **Red light** has the **longest wavelength** and **lowest frequency**.
 - **Violet light** has the **shortest wavelength** and the **highest frequency**.
- c) Each colour of the spectrum has its own **frequency** and **wavelength**.
- 3) **Wavelength**: distance between 2 successive crests or trough of a wave. **Wavelength**: is the *length of each wave*.



- Light can **travel through solids, liquids, gases** and **through space as waves**, which resembles waves of water. It is called a **wave** because it **moves in a repetitive up and down motion**.

Wavelength

- 4) **Frequency**: is the **number of waves** that pass a point in **one second**.

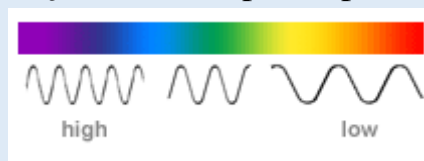


Figure 3

Frequency

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- **Violet light** has *the highest frequency* and the *shortest wavelength*.
 - *Higher frequency colours* are - violet - indigo – blue and *lower frequency colours* are - yellow - orange - red.
- 5) The visible spectrum is divided into 3 regions.
- a) *The red region* – orange, red form a **bright red** called **Primary red**
 - b) *The green region* – yellow, green form a bright green called **Primary green**.
 - c) *The blue region* – blue, indigo and violet form a dark blue called **Primary blue**.
- 6) The primary colours of light are red, blue and green

OPAQUE AND TRANSPARENT SUBSTANCES**OPAQUE SUBSTANCES**

- 1) **Opaque substances:** materials that *do not allow light to pass through* them. The light is *either absorbed or reflected*. Examples are wood, paper, some plastics, metals and clothes
- 2) **Shadows:** are *darker areas* that *form behind opaque objects* because the *light is unable to travel through* the object as light travels in straight lines.
 - A **shadow** is *always cast on the side of the object that faces away from the light source*. The **area** where **light is absent** appears *black to the eye*.
 - The *shape of the shadow* is the *same as the shape of the object*.
 - The *length of the shadow depends* on the *distance of light from the object*.
 - The reason why we *cannot see through a wall*, it's because the *wall is an opaque object that prevents the light from passing through it, instead the light is absorbed by the wall or reflected off the wall*.
 - **The phases of the Moon** are due to shadows that are formed.

- i. When the Moon is *directly between the Sun and Earth*, we can see *only the dark side of the Moon*. The *illuminated side is facing away from us*. This is called **New Moon**.
- ii. When the *Earth is directly between the Sun and the Moon*, we can see the *whole surface of the Moon* that is **lit**. The shadow side is facing away from us. This is called **Full Moon**.

TRANSPARENT SUBSTANCES

- 1) **Transparent object:** any object that *allows light to travel through it*. Examples are glass, clear plastic, cellophane and clean water, Air.
- 2) When light strikes a transparent object, *some of the light is absorbed and reflected* but *most of the light passes through the object*.
 - Transparent objects *do not cast shadows*.
 - When a *clear image can be seen through an object*, it means that *all light has passed through*.
- 3) **A translucent object:** *allows light to pass through it*, but this light is **scattered** in *many directions* and *does not form a clear image*.
 - Examples are *tissue paper, frosted glass and certain plastics*.
 - The *translucent objects will make a shadow*, **bathroom windows** are *often made from translucent glass*, such as frosted glass. The *light is scattered in different directions* by the frosted glass, **which results in a cloudy, blurred or distorted image**.

ABSORPTION OF LIGHT

- **White light is made up of 7 different colours** that correspond to different frequencies of light.
 - **Light is absorbed by the surfaces** of some materials and different materials absorb light differently.
- a) A material has colour because it *absorbs some of the colours/frequencies in the spectrum*, while *reflecting other colours*. We call this **selective absorption**.

- b)** When *light shines on a coloured object*, the *object absorbs all the colours* but *reflects* the colour of the object.
- c)** When *all light is completely absorbed by an object*, the **surface** of the *object appears black*. The frequencies that are absorbed do not reach the eye. We *can only see those colours that are reflected and enter our eyes*.
- d)** A *black object absorbs all of the frequencies* or colours of white light, and *no light is reflected*.
- e)** A *white object reflects all the frequencies/* colours of white light & *does not absorb any colours*.
- f)** The **colours that are absorbed do not reach the eye**. The frequencies that have been reflected will reach the eye and will give colour to the object.

EXAMPLE

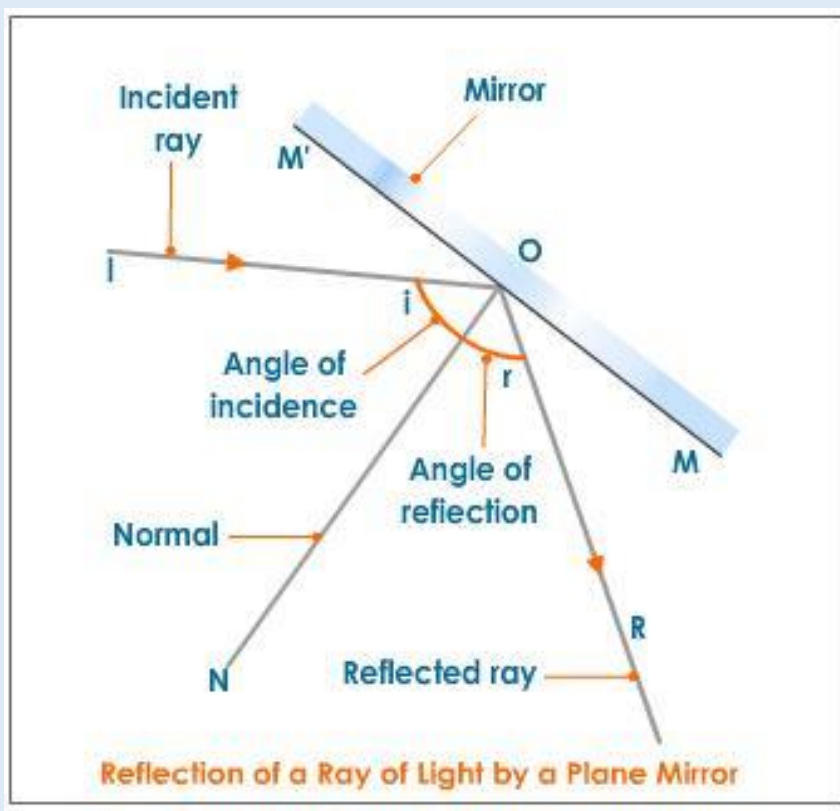
- ❖ The **flowers appear red** because they have *absorbed all the frequencies of violet, indigo, blue, green, yellow and orange of the sunlight*, and *only reflected the frequency of red light*.
- Since *red light is the only light that reaches the eye*, the flowers appear to be red.

REFLECTION OF LIGHT

- 1) Reflection:** *bouncing back of light* when striking a surface
 - *Some objects reflect the light of luminous objects* e.g. the moon reflecting the light from the sun.
 - The way in which light is reflected from a surface *depends on the nature of the surface*.
- i.** A *smooth surface reflects light that is striking it, straight away* (to an observer the surface looks shiny. This is called **regular reflection**). A mirror is an example of regular reflection.
- ii.** A *rough surface* will also *reflect light, but the reflection looks dull* (light is reflected in all directions, depending on the angle of the part it strikes. This is called **diffused reflection**).

REFLECTION BY PLANE (FLAT) MIRRORS:

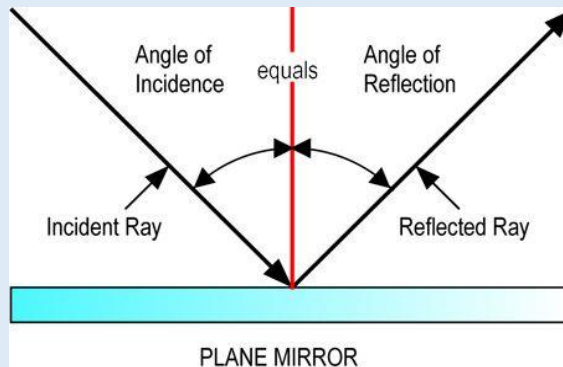
1. *Reflection occurs when **light bounces off an object**. The light changes direction when it is reflected off an object.*
2. When *light strikes a reflective object* such as a mirror, the **light reflects back** at the same angle, e.g. if you shine a light straight onto the mirror, the **light will reflect straight back**.
3. The light ray is called the **incident ray** while the reflecting ray is called the **reflected ray**.
4. The angle that the incident ray is shone at is called the **angle of incidence** while the angle the reflected ray leaves at is called the **angle of reflection**.



- If a *surface is flat and smooth* (as seen above) **all light will be reflected in the same direction**.
 - *Irregular or rough surfaces*, as on a lake with ripples, will *scatter the reflections*.
5. The law of reflection states “the **angle of incidence** is equal to the **angle of reflection**”.
- a) The incident ray: is the **light ray** that **strikes the surface** of an object.

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- b) **The reflected ray:** is the *light ray* that is *reflected off the surface* of an object.
- c) **The normal:** is a *line drawn at right angles* to the surface of an object.
- d) The *angle of incidence is between the incidence ray and the normal.*
- e) The *angle of reflection is between the reflecting ray and the normal.*



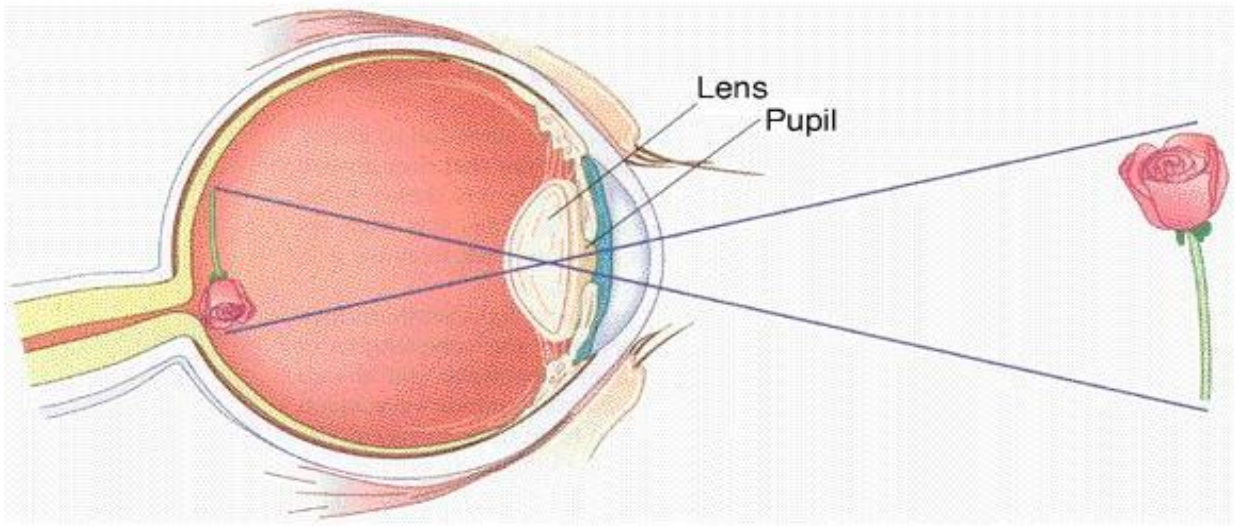
- *The closer you move towards the mirror, the closer your image gets.*
- When you move to the right, *your image also moves to the right.*
- Red, blue & green colours are called **Primary colours of light.**
- Combining the primary colours of light produces the **secondary colours.**

SEEING THE LIGHT

- 1) When light shines on coloured objects, *some of the light is absorbed* and *some of the light is reflected* by the object.
 - a) *Light enters the eye at the pupil* and is focused to form an image on the *retina at the back of the eye.*
 - b) On the surface of the retina are *special cells* called *photoreceptors* that are *sensitive to light.*
 - c) The **image** that is formed on the retina is **upside down.**
 - d) The light-sensitive cells come together at the back of the eye to form the optic nerve.
 - e) The **light energy** that strikes a cell in the retina is *converted to electrical nerve impulses.*

- f) These impulses pass along the optic nerve to the *visual centre at the back of the brain* where the *brain interprets the signals and provides us with an upright image*.

The Formation of the Retinal Image. Figure 7.3

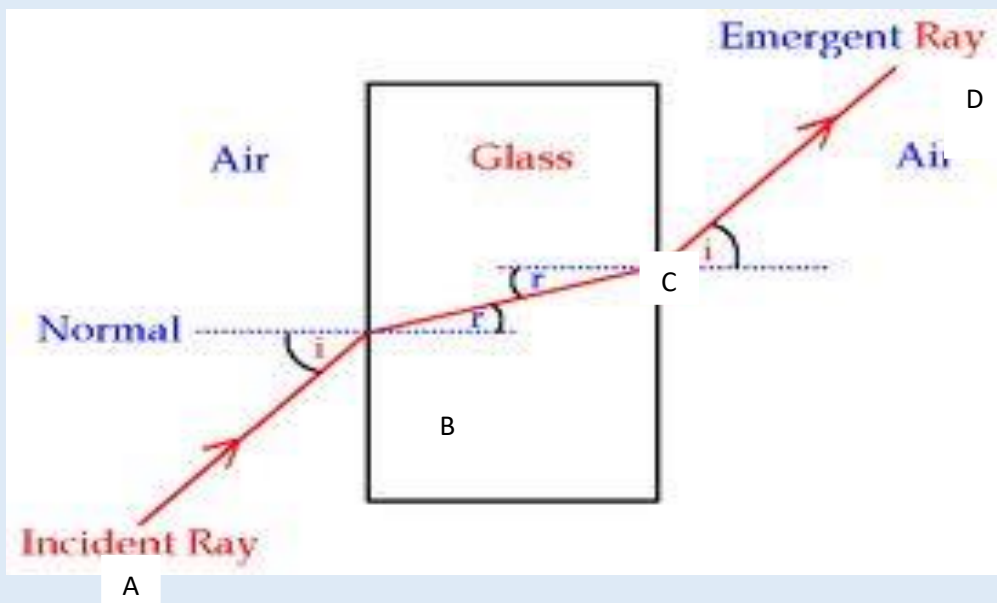


❖ **Example: when we see a Red lollipop.**

- i. When *light shines on the red lollipop*, it *absorbs all the frequencies of visible light* and reflects *the frequency associated with red colour*.
- ii. The *absorbed frequencies of visible light do not reach the eye, only colour that reaches the eye is the red light*.
- iii. The colour *passes through the pupil* of the eye and is *focused on the retina* at the back of the eye.
 - On the retina, are *Photoreceptors* are either *cones or rods*.
 - The rods and cones in the retina of the eye are cells that respond to light.
 - The *rods operate in dim light* and are very sensitive to light and we *see only shades of grey*.
 - The *cones respond to bright light* and there are 3 different types of cones that respond to red, blue and green light
- iv. *An upside-down image* is formed on the retina.
- v. The *brain interprets* the impulses to *form a picture* and our perception of light.

REFRACTION OF LIGHT

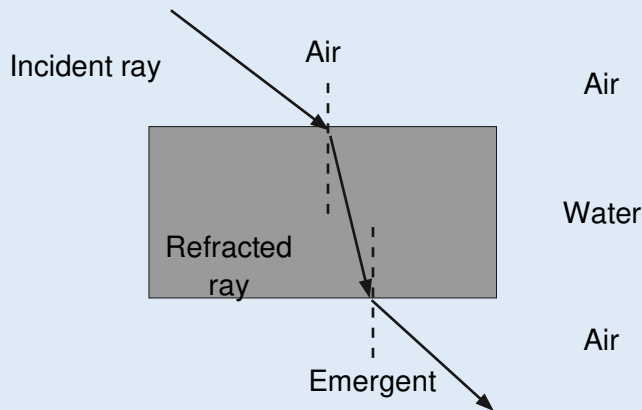
- 1) **Refraction of light:** is the *change in direction of light/bending of light* when it *travels from one optical medium to the other* of different optical density (eg *from air through a clear material it can bend*).
- Water, air and glass; air have the *smallest optical density*, and glass the *greatest optical density*. So, when a light ray enters a more dense optical medium, it is *refracted towards (closer to) the normal* and *vice versa*.
- Although light travels in straight lines, the direction of light can be changed when it is reflected or refracted, for-instance *Glass has a higher optical density than water*, while *air has the lowest optical density*.
- 2) As the light travels at different speeds in the different materials this change in direction is called **refraction**.
- 3) When a *light ray enters an optically dense medium*, the *speed of light will decrease*, and the *light ray will bend towards the normal* in that medium.
- 4) When a *light ray enters a less optically dense medium*, the *speed of light will increase*, and the *light ray will bend away from the normal* in the medium.



- ❖ **Example of Refraction of light as it travels from air to water and back into the air.**

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- Incident ray enters water at an angle.
- *Water is optically denser than air*, therefore *light slows down as it enters the water*.
- At the boundary between the air and the water, *light bends closer to the normal*. This is called the **refracted ray**. The Normal is a line perpendicular to the surface of a medium and we *draw it as a broken line*.
- As the *light leaves the water*, it travels back into the air, which is *less optical dense than water*.
- The *light speeds up and changes direction away from the normal*. This is called the **emergent ray**. **The emergent ray is parallel to incident ray.**



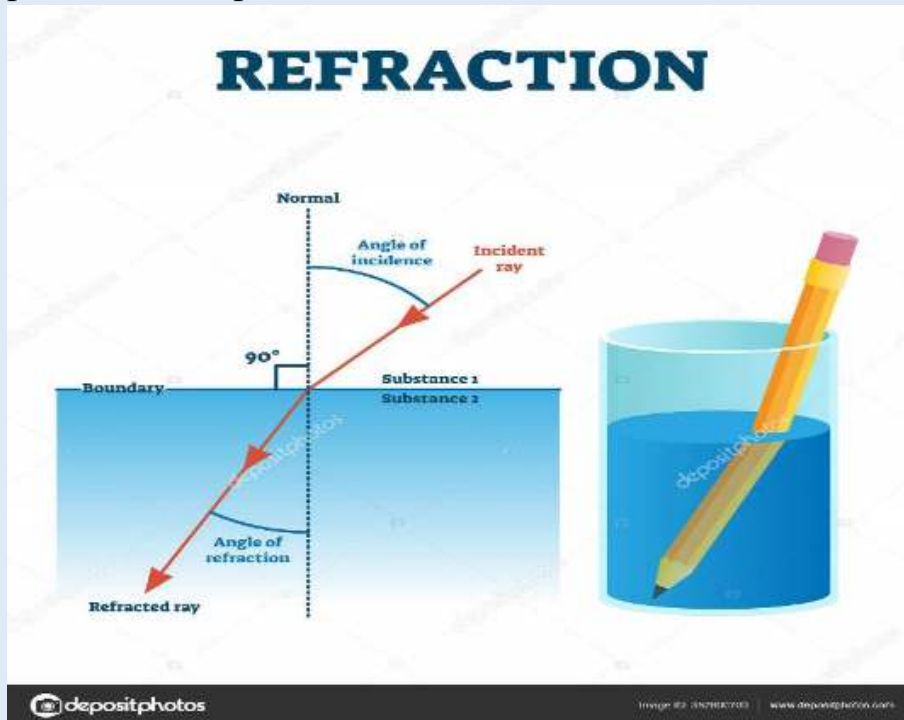
- 1) *Light rays changes direction* as it *passes through one medium to another*. This sudden change of direction is known as **refraction (bending)**.
- 2) The *light ray slows down the speed & causes bending* due to the *difference in density [air is less dense than the prism]* or the prism is denser than air.
 - *Light ray always bends towards the normal* when *entering the medium*, and *away from normal when leaving*.
- 3) When *light enters* a triangular prism at an angle, the *white light is split into different colours*.
- 4) The *different colours move* at *different speeds* through the prism because of their *different wavelengths and frequencies*.

- 5) The **different colours** of light *bend at different angles* and that is why we *see these colours*. *Red light is bent the most and violet light the least.*

A **rainbow** forms after a storm because tiny drops of water in the air *act as tiny prisms*. They *refract and disperse the sunlight* into the colours of the rainbow.

DEMONSTRATION OF REFRACTION

- Insert a pencil in a glass of clean water and observe the apparent change in position of the pencil below the surface of the water.



OBSERVATIONS	EXPLANATION
Pencil look broken	<i>It's because the light that is reflected off the pencil is bent and the phenomenon is called Refraction.</i>
There are 2 optical mediums with different optical density	<i>Water is optically denser than ai, this causes refraction to take place.</i>
There's bending of light that take place	<i>Refraction occurs at the water-air boundary.</i> <i>*Glass that contains pencil and water is too thin to show a lot of refraction.</i> <i>*The light from the part of the pencil above the water travels straight to our eyes.</i>

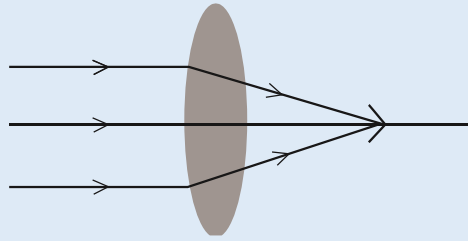
**The light from the part of the pencil in the water is bent as it leaves the water and enters the air.*
**The light speeds up in the air and changes direction away from the normal.*

THE FORMATION OF IMAGES BY PLANE MIRRORS

- While ***standing in front of a mirror***, you may be able to identify the following characteristics regarding your image:
 1. The image is just as far behind the mirror as the object is in front of it.
 2. The image has the same size as the object.
 3. The image is laterally inverted.
 4. The image is virtual because light rays do not really travel up to the image

APPLICATIONS OF THE REFRACTION OF LIGHT

- 1) A magnifying glass is also a type of lens that is able to refract and focus light. Whenever you use eyeglasses, a telescope, binoculars or fibre optics technology, you are using the refraction of light. It looks shallower.
- 2) When an object is in water, its image appears to be shallower. This is the result of the refraction of light rays.
 - a) ***Air is less dense than water***. As the light rays leave the water, they speed up and bends away from the normal.
 - b) Our eyes can only see in straight lines, so our brains extend the paths of the light rays to where they expect the object to be.
- 3) A lens is made of a transparent material with a different optical density than air. ***A lens is able to refract and focus light***, because its surface is ***curved to refract light*** in a specific way. The light is refracted at each boundary. Lenses are used in reading glasses to correct a person's vision or enhance it by making distant objects appear closer or small objects appear bigger.



- 4) A ***magnifying glass enlarges an object***. It creates an image that is virtual and larger than the object. The light is bent by the lens so that it appears to come from a much larger object.