PHYSICS

In Physics, we study a large number of physical quantities, which can be broadly classified into two categories : scalars and vectors.

Scalar Quantities: Physical quantities which have magnitude only. e.g. Mass, speed, volume, work, time, distance, power, energy, etc. are scalar quantities.

Vector Quantities: Physical quantities, which have magnitude and direction both, e.g., Displacement, velocity, acceleration, force, momentum, torque, etc. For a quantity to be a vector, it is necessary that it follows the triangle rule of addition of two vectors

NEWTON'S LAWS OF MOTION

First Law: Every body maintains its initial state of rest or uniform motion on a straight line unless any external force acts on it. It is also called **Galileo's law of inertia.**

Example: While jumping from a slowly moving train/bus one must run for a short distance, in the direction of motion.

Second Law: The force acting on an object is directly proportional to the product of the mass of the object and the acceleration produced on it.

Third Law: To every action, there is an equal and opposite reaction.

Example: Bogies of the trains are provided with buffers to avoid severe jerks during shunting of trains.

Rocket moves up due to the reaction of downward ejection of gas.

CIRCULAR MOTION

- When an object moves along a circular path, its motion is called circular motion.
- The direction of motion at any point in circular motion is given by the tangent to the circle at that point.
- The external force required to act radially inward over the circular motion of the body is called **centripetal force**.
- In the death well, the walls of well exert an inward force over the motorcycle and as a reaction, the motorcycle exert an outward force on the walls of the well
- **Centrifugal force** is such a pseudo force that is equal and opposite to centripetal force.
- Cream separator, centrifugal dryer work on the principle of centrifugal force.

FRICTION

It is the opposing force that is set-up between the surfaces of contact of two bodies when one body slides or rolls or tends to do so on the surface of another body.

- Due to friction we are able to move on the surface of Earth.
- On applying brakes in automobiles, it stops only due to friction.

Important Links for Judiciary Free Resources (Click on Each to Open Respective Pages)	
Subject Wise Mains PYQ Solution	Essay for Judiciary
Subject Wise Notes	Legal Doctrines
Landmark Judgements	GS Notes
Weekly Current Affair	Subject Wise Prelims PYQ Solution
Free Answer Writing Course	Judgement Writing
Telegram Link	Youtube Link

WORK

Work is said to be done, if force acting on a body is able to actually move it through some distance in the direction of the force. Its SI unit is joule.

$$\text{Work} = Fs\cos\theta$$

where, F = force, s = displacement and θ is the angle between the direction of force and displacement.

- If $\theta > 90°$, then work will be negative.
- If $\theta < 90°$, then work will be positive.
- If $\theta = 90°$, then work will be zero.

ENERGY

Capacity of doing work by a body is called its energy. Energy is a scalar quantity and its unit is **joule**. Mechanical energy is of two types.

- Kinetic Energy (K) Energy possessed by a body due to its motion.

$$K = \frac{1}{2}mv^2$$

where, *m* is mass and *v* is the velocity

- **Potential Energy** (*U*) The capacity of doing work developed in a body due to its position or configuration.

$$U = mgh$$

where, m is mass, *g* is acceleration due to gravity and *h* is height.

- The sum of all kinds of energies in an isolated system remains constant at all times. This is the law of conservation of energy.

POWER

Rate of doing work is called power. Its unit is **watt**

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}}$$

- 1 watt hour = 3600 joule
- 1 kilowatt hour = 3.6 x 10^6 joule
- 1 HP = 746 watt

GRAVITATION

- Everybody in the universe attracts other body by a force called force of **gravitation.**
- The gravitational force of the earth is called gravity.
- The acceleration produced in a body due to force of gravity is called **acceleration** due to gravity (g) and its value is **9.8 m s/^{2}** .
- Acceleration due to gravity is independent of shape, size and mass of the body.
- Escape velocity is the minimum velocity with which an object just crosses the Earth's gravitational field and never returns. Escape velocity at the Earth's surface is **11.2 km/s**.
- Escape velocity at the Moon's surface is **2.4 km/s**. Due to low escape velocity there is no atmosphere on the Moon.
- Value of *g* decreases with height or depth from Earth's surface.
- *g* is maximum at poles
- *g* is minimum at equator
- *g* decreases due to rotation of Earth.
- *g* decreases if angular speed of Earth increases and increases if angular speed of Earth decreases.
- The acceleration due to gravity at the is one-sixth that of the Earth. So, the weight of a person on the surface of the Moon will be one-sixth of his actual weight on the Earth

SATELLITES

- Satellites are natural or artificial bodies revolving around a planet under its gravitational force of attraction.
- **Moon** is a natural satellite, while INSAT-B is an artificial satellite of Earth
- The period of revolution of satellite revolving near the surface of Earth is 1 hour 24 minutes (84 minutes).
- Geo-stationary satellite revolves around the Earth at a height of 36000 km (approx). The orbit of geo-stationary satellite is called parking orbit. Geo-stationary satellite revolves in equatorial plane from West to East. Time period of rotation of geo-stationary satellite is **24 h**.
- The **Earth** rotates on its axis from **West** to **East**. This rotation makes the Sun and the stars appears to be moving across the sky from East to West
- Geo-stationary satellite is used to telecast TV programmes from one part of the world to another, in weather forecasting, in predictions of floods and droughts.
- **Polar satellite** revolves around the Earth in polar orbit at a height of **800 km** (approx). Time period of these satellites is **84 min**.
- These are used for weather forecasting, mapping, etc.

GENERAL PROPERTIES OF MATTER

Elasticity

Elasticity is the property of material of a body by virtue of which the body acquires its original shape and size after the removal of **deforming force**

- A force, which changes the configuration of a body, is called a **deforming force.**
- Steel is more elastic than rubber.

Pressure

Pressure is defined as force acting normally on a unit area of the surface

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Its unit is **N/m²** . It is a scalar quantity

- Atmospheric pressure is measured by an instrument called the **barometer**
- Sudden fall in barometric reading is the indication of storm.
- Slow fall in barometric reading is the indication of rain.
- Slow rise in the barometric reading is the indication of clear weather.
- The pressure exerted by liquid column at the surface given as **p = hdg** , where d is the density of liquid and h is height of liquid column. In a static liquid at same horizontal level, pressure is same at all points.

Atmospheric pressure decreases with altitude.
That is why:

- ❖ It is difficult to cook on the mountain.
- ❖ The fountain pen of a passenger leaks in aeroplane.
- ❖ Bleeding occurs from the nose.
- ❖ It is difficult to breath on higher altitude due to less amount partial pressure of oxygen in air.
- ❖ Water starts to boil below 100°C

Pascal's Law of Pressure

- ➢ If gravitational attraction is negligible in equilibrium condition, (approx) pressure is same at all points in a liquid.
- ➢ The pressure exerted anywhere at a point of confined liquid is transmitted equally and undiminished in all directions throughout the liquid.
- ➢ Hydraulic lift, hydraulic press and hydraulic brakes are based on the Pascal's law of pressure

Archimedes' Principle

When a body is immersed partly or wholly in a liquid, there is an apparent loss in the weight of the body, which is equal to the weight of liquid displaced by the body.

- The weight of water displaced by an iron ball is less than its own weight whereas water displaced by the immersed portion of a ship is equal to its weight. So, small balls of iron sink in water, but large ships float.
- A fat person will quickly learn the swimming as compared to a slim person because he will displace more water. So, he will be more balanced.
- Hydrogen filled balloons float in air because hydrogen is lighter than air.
- A person can lift more weight in water.

Laws of Floatation

A body floats in a liquid if:

- The density of material of the body is less than or equal to the density of liquid.
- When the density of material of the body is equal to density of liquid, the body floats fully submerged in liquid in neutral equilibrium.
- When the body floats in neutral equilibrium, the weight of the body is equal to the weight of displaced liquid. The centre of gravity of the body and centre of gravity of the displaced liquid should be in one vertical line for this condition.

Density

- ➢ Density is defined as mass per unit volume.
- ➢ Relative density is measured by **hydrometer.**
- ➢ The density of sea water is more than that of normal water.
- ➢ When a ship enters the sea from a river, it rises a bit because the density of saline water (salt water) is higher.
- ➢ The density of iron is more than that of water, but less than that of mercury. So, a solid chunk of iron sinks in water but floats in mercury.
- ➢ If ice floating in water in a vessel melts, the level of water in the vessel does not change

Surface Tension

- ➢ It is the force (F) acting normally on unit length (l) of imaginary line drawn on the surface of liquid i.e., $T = \frac{F}{l}$, its unit is N/m

- The property of a liquid by virtue of which it tries to minimise its free surface area is called the surface tension.
- Surface tension decreases with rise in temperature and becomes zero at the critical temperature.
- The surface tension of clean water is higher than that of a soap solution.
- Formation of lead shots, spraying result in coldness, floatation of needle on water, dancing of camphor on water, are based on surface tension.
- Rain drop form spherical shape due to surface tension.
- When kerosene oil is sprinkled on water, its surface tension decreases, due to which the excess of mosquitoes floating on the surface of water die due to sinking.

Cohesive and Adhesive Forces

Force of attraction applied between molecules of same substance is called **cohesive force** while attractive force between molecules of different substances is called **adhesive force**

Capillarity

The phenomenon of rise or depression of liquids in a capillary tube is called capillarity

- A piece of blotting paper soaks ink because the pores of the blotting paper serve as capillary tubes.
- The oil in the wick of a lamp rises due to capillary action of threads in the wick.
- The root hairs of plants draws water from the soil through capillary action.

Viscosity

Viscosity is the property of a fluid by virtue of which an internal frictional force acts between its layers, when it is in motion

Bernoulli's Theorem

When an incompressible and non-viscous liquid (or gas) flows in streamlined motion from one place to another, then at every point of its path the total energy per unit volume (pressure energy + kinetic energy + potential energy) is constant.

Venturimeter, Atomizer, filter pump, motion of aeroplane are based upon the Bernoulli's theorem.

Important Links for Judiciary Free Resources (Click on Each to Open Respective Pages)	
Subject Wise Mains PYQ Solution	Essay for Judiciary
Subject Wise Notes	Legal Doctrines
Landmark Judgements	GS Notes
Weekly Current Affair	Subject Wise Prelims PYQ Solution
Free Answer Writing Course	Judgement Writing
Telegram Link	Youtube Link

HEAT AND THERMODYNAMICS

Heat

- Heat is a form of energy, which measures the sensation or perception of warmness or coldness of a body or environment.
- Its units are calorie, kilocalorie or joule.
- 1 calorie = **4.18** joule.

Temperature

- Temperature is the measurement of hotness or coldness of a body.
- When two bodies are placed in contact, heat always flow from a body at higher temperature to the body at lower temperature

- An instrument used to measure the temperature of a body is called a thermometer.
- The normal temperature of a human body is 37°C or 98.4°F.
- − ° 40 is the temperature at which Celsius and Fahrenheit thermometers read the same.
- The clinical thermometer reads from 96°F to 110°F.
- White roof keeps the house cooler in summer than black roof because white roof reflects more and absorbs less heat rays whereas black roof absorbs more and reflects less heat rays.
- Ice wrapped in a blanket does not melt away quickly because a woollen blanket is a bad conductor of heat.
- Sliver is the best conductor of heat.
- Cooking utensils are made of aluminium, brass and steel because these substances have low specific heat and high conductivity

Thermal Expansion

- Thermal expansion is the increase in size on heating.

- *A solid can undergo three types of expansions*
  - Linear expansion
  - Superficial expansion
  - Cubical expansion

- Telephone wires are kept loose to allow the wires for contraction in winter.
- A gap is provided between two iron tracks of the railway track, so that rails can easily expand during summer and do not bend.

Specific Heat

- The amount of heat required to raise the temperature of unit mass of a substance through 1°C, is called its specific heat.

- When temperature of water is increased from 0°C, then its volume decreases upto 4°C, becomes minimum at 4°C and then increases.

- This behaviour of water around 4°C is called anomalous expansion of water.

Latent Heat

- The heat energy absorbed or released at constant temperature per unit mass for change of state is called the latent heat.

- Latent heat of fusion of ice is **80 cal/g.**

- Latent heat of vaporisation of steam is **536 cal/g.**

- Hot water burns are less severe than that of steam burns because steam has high latent heat.

Evaporation

- It is the slow process of conversion of liquid into its vapour even below its boiling temperature.

- The amount of water vapour in air is called humidity.

- Relative humidity is measured by hygrometer.

- Relative humidity increases with the increase of temperature.

Transmission of Heat

- Transfer of heat from one place to other place is called transmission of heat.

- In solids, transmission of heat takes place by conduction process.

- In liquids and gases, transmission of heat takes place by convection process. In room, ventilators are provided to escape the hot air by convection.

- Heat from the Sun reaches the Earth by radiation.

Simple Pendulum

- Simple pendulum is a heavy point mass suspended from a rigid support by means of an elastic and inextensible string.
- The maximum time period of a simple pendulum is **84.6 min.**

- The time period of a simple pendulum does not depend upon the mass, shape and size of the bob and its amplitude of oscillation. A pendulum clock goes slow in summer and fast in winter.

- If a simple pendulum is suspended in a lift descending down with acceleration, then the time period of the pendulum will increase. If lift is ascending, then the time period of the pendulum will decrease.

- If a lift falls freely under gravity, then the time period of the pendulum is infinite.

WAVES

A wave is a disturbance, which propagates energy from one place to the other without the transportation of matter.

Waves are broadly of two types:

i. Mechanical wave (longitudinal wave and transverse wave)
ii. Electromagnetic wave

Longitudinal Waves

In this wave, the particles of the medium vibrate in the direction of propagation of wave.
Waves on springs or sound waves in air are examples of longitudinal waves.

Transverse Waves

In this wave, the particles of the medium vibrate perpendicular to the direction of propagation of wave.
Waves on strings under tension, waves on the surface of water are the examples of transverse waves

Electromagnetic Waves

- ➢ The waves, which do not require medium for their propagation i.e., which can propagate even through the vacuum are called electromagnetic waves.
- ➢ Light radio waves, X-rays, etc. are the examples of electromagnetic waves. These wave propagate with the velocity of light in vacuum.

Sound Waves

- ➢ Sound waves are longitudinal mechanical waves. Based on their frequency range sound waves are divided into following categories.
- ➢ The sound waves which lie in the frequency range **20 Hz to 20000 Hz** are called audible waves.
- ➢ The sound waves having frequencies less than **20 Hz** are called infrasonic waves.
- ➢ The sound waves having frequencies greater than **20000 Hz** are called ultrasonic waves.
- ➢ Ultrasonic waves are used for sending signals, measuring the depth of sea, cleaning machinery parts located in hard to reach places, such as spiral tubes, etc.

Speed of Sound

- Speed of sound is maximum in solids and minimum in gases.
- When sound goes from one medium to another medium, its speed and wavelength changes, but frequency remains unchanged.
- The speed of sound remains unchanged by the increase or decrease of pressure. .
- The speed of sound increases with the increase of temperature of the medium.
- The speed of sound is more in humid air than in dry air because the density of humid air is less than the density.

Echo: The repetition of sound due to reflection of sound waves, is called echo.

Intensity: It is defined as the amount of energy passing per unit time through a unit area that is perpendicular to the direction in which sound waves are travelling.

Pitch: The sensation of a frequency is commonly referred to as the pitch of a sound.

SONAR: It stands for sound navigation and ranging. It is used to measure the depth of a sea, to locate the enemy submarines and shipwrecks.

Doppler's Effect

- If there is a relative motion between source of sound and observer, the apparent frequency of sound heard by the observer is different from the actual frequency of sound emitted by the source. This phenomenon is called Doppler's effect.

- When the distance between the source and observer decreases, then apparent frequency increases and *vice-versa.*

Important Links for Judiciary Free Resources (Click on Each to Open Respective Pages)	
Subject Wise Mains PYQ Solution	Essay for Judiciary
Subject Wise Notes	Legal Doctrines
Landmark Judgements	GS Notes
Weekly Current Affair	Subject Wise Prelims PYQ Solution
Free Answer Writing Course	Judgement Writing
Telegram Link	Youtube Link

LIGHT

- Light is a form of energy, which is propagated as electromagnetic wave.

- It is the radiation which makes our eyes able to see the object. Its speed is 3 10^8 × m/s. It is the form of energy. It is a transverse wave. It takes 8 min 19 s to reach on the Earth from the Sun and the light reflected from Moon takes 1.28 s to reach Earth.

Reflection of Light

When a ray of light falls on a boundary separating two media comes back into the same medium, then this phenomenon is called reflection of light.

Laws of Reflection

- The incident ray, reflected ray and the normal to the reflecting surface at the incident point all lie in the same plane.

- The angle of reflection is equal to the angle of incidence

Reflection from Plane Mirror

- The image is virtual and laterally inverted.
- The size of image is **equal** to that of object.
- If an object moves towards a plane mirror with speed *v*, relative to the object the image moves towards it with a speed 2*v*.
- To see his full image in a plane mirror, a person requires a mirror of at least half of his height.
- The number of images formed by two plane mirrors, inclined by an angle θ,

$$n = \left(\frac{360^\circ}{\theta} - 1\right)$$

Spherical Mirror

- *Spherical mirrors are of two types* (i) Concave mirror (ii) Convex mirror
- Image formed by a convex mirror is always virtual, erect and diminished.
- Image formed by a concave mirror is generally real and inverted

Uses of Concave Mirror

(i) As a shaving glass.
(ii) As a reflector for the headlights of a vehicle, search light.
(iii) In an ophthalmoscope to examine the eye, ear, nose by doctors.
(iv) In solar cookers.

Uses of Convex Mirror

(i) As a rear view mirror in a vehicle because it provides the maximum rear field of view and image formed is always erect.
(ii) In sodium reflector lamp

Refraction of Light

The bending of the ray of light passing from one medium to another medium is called refraction. When a ray of light enters from one medium to another medium, its frequency and phase do not change, but wavelength and velocity change. Due to refraction from Earth's atmosphere, the stars appear to twinkle.

Critical Angle

The angle of incidence in a denser medium for which the angle of refraction in rarer medium becomes 90°, is called the critical angle

Total Internal Reflection (TIR)

If light is travelling from denser medium to rarer medium and the angle of incidence is more than the critical angle, then the light is reflected back into the denser medium. This phenomenon is called total internal reflection.

Sparkling of diamond, mirage and looming, shining of air bubbles in water and optical fibre are examples of total internal reflection.

Optical Fibre

It works on the principle of TIR. It is used for telecommunication and various medical purposes like endoscopy

Lens

- Lens is generally of two types (i) Convex lens (ii) Concave lens
- When the lens is dipped in a liquid of higher refractive index, the focal length increases and convex lenses behave as concave lenses and vice-versa.
- An air bubble trapped in water or glass appears as convex, but behaves as a concave lens.

Dispersion of Light

- When a ray of white light is passed through a prism, it gets splitted into its constituent colours. This phenomenon is called **dispersion of light.**
- The different colours appearing in the spectrum are in the following order, violet, indigo, blue, green, yellow, orange and red **(VIBGYOR).**
- Rainbow is formed due to dispersion of sunlight by water droplets.

➢ Wavelength of the red colour is maximum and the violet colour is minimum.

➢ Red, green and blue are **primary** colours. Green and magenta, blue and yellow, red and cyan are complementary colours.

Scattering of Light

➢ When light passes through a medium in which particles are suspended whose sizes are of the order of wavelength of light, then light striking on these particles deviates in different directions. Scattering of light is maximum in case of violet colour and minimum in case of red colour.

➢ Blue colour of the sky is due to scattering of blue and violet light. The brilliant red colour of rising and setting sun is also due to scattering of light.

HUMAN EYE

➢ It is an optical instrument like a camera. It forms the real image of the object on the retina of the eye. Least distance of distinct vision is 25 cm.

Defects of Eye	
Myopia (Short sightedness)	A short-sighted eye can see only nearer objects. Distant objects are not seen clearly. This defect can be removed by using concave lens of suitable focal length.
Hypermetropia (Long sightedness)	A long sighted eye can see distant objects clearly but nearer object are not clearly visible. This defect can be removed by using a convex lens.
Presbyopia	In this defect both near and far objects are not clearly visible. It can be removed by using bi-focal lens
Astigmatism	In this defect eye cannot see horizontal and vertical lines clearly. This defect can be removed by using suitable cylindrical lenses

Microscope

- **Simple** microscope is a convex lens of small focal length.

- **Compound microscope** is a combination of two convex lenses, called objective lens and eyepiece, separated by a distance.

- **Astronomical Telescope** is also a combination of two lenses in which objective lens is a convex lens of large aperture and large focal length while eye-piece is a convex lens of small aperture and small focal length.

ELECTRICITY AND MAGNETISM

Charge

Charge is the basic property associated with matter due to which it produces and experiences electric and magnetic effects. Similar charges repel each other and opposite charges attract each other. The SI unit of charge is **coulomb.**

Conductor	Conductors are those materials, which allow electricity to pass through themselves. Metals like silver, iron, copper and earth act like a conductor. **Silver** is the best conductor.
Insulator	Insulators are those materials which do not allow electricity to flow through themselves. Wood, paper, mica, glass, and ebonite are insulators.

Electric Current

- Electric current is defined as the rate of flow of charge or charge flowing per unit time. Its unit is **ampere**. It is a scalar quantity.
- A lightning conductor is fixed on tall buildings to protect them from the destructive effects of the lightning.
- An electric bulb produces a bang when it is broken because there is a vacuum inside the electric bulb, when the bulb is broken air rushes at great speed from all sides to fill the vacuum. The rushing of air produces a noise generally referred to as the **bang**.

Ohm's Law

At the constant physical conditions of any conductor, the current flowing through the conductor is directly proportional to the potential difference across it

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

where *R* is the resistance.

- If a wire is stretched, its resistance will change but its specific resistance will remain unaffected
- On increasing the temperature of the metal, its resistance increases.
- On increasing the temperature of the semiconductor, its resistance decreases.
- On increasing the temperature of electrolytes, its resistance decreases.
- The reciprocal of resistivity of a conductor is called its **conductivity**. Its unit is mho $\mathbf{m^{-1}}$.
- The heating effect of electric current is known as **Joule's law of heating.**

- Electric bulb, electric kettle, heater, etc devices work on the basis of heating effect of electric current.

Ammeter: It is a device which is used to measure electrical current. It is connected in series. The resistance of an ideal ammeter is zero.

Voltmeter: It is a device used to measure the potential difference between two points in a circuit. It is connected in parallel to the circuit. The resistance of an ideal voltmeter is infinite.

Fuse Wire: It is a small conducting wire of alloy of copper, tin and lead having low melting point. So, it is a protective device used in series.

MAGNETS

- ➢ Magnet is a piece of iron or other materials that can attract iron containing object and points toward North when suspended
- ➢ When a magnet is freely suspended, it's one pole always directed towards the North. This pole is called the North pole. The other pole is called South pole
- ➢ Like poles of a magnet repel each other and unlike poles attract each other.
- ➢ A current carrying coil containing a soft iron core, is called an electromagnet, which is utilised in electric bell, telegraph receiver, telephone, transformer, dynamo, etc

Important Links for Judiciary Free Resources (Click on Each to Open Respective Pages)	
Subject Wise Mains PYQ Solution	Essay for Judiciary
Subject Wise Notes	Legal Doctrines
Landmark Judgements	GS Notes
Weekly Current Affair	Subject Wise Prelims PYQ Solution
Free Answer Writing Course	Judgement Writing
Telegram Link	Youtube Link

ATOMIC AND NUCLEAR PHYSICS

Cathode Rays

Cathode ray was discovered by **Sir William Crooke** and its properties are:

- ➢ These rays travel in straight lines.
- ➢ These rays produce fluorescence.

- These rays can penetrate through thin foils of metal and are deflected by both electric and magnetic fields.
- These rays have velocity ranging **1/30th** to **1/10th** of the velocity of light.

Positive or Canal Rays

- These rays were discovered by Goldstein.
- The positive rays consist of positively charged particles.
- These rays travel in a straight line.
- These rays are deflected by electric and magnetic fields.
- These rays are capable of producing physical and chemical changes.
- These rays can produce ionisation in gases

X-Rays

- X-rays are electromagnetic waves with wavelength range 0.1 Å−100 Å. X-rays were discovered by **Roentgen.**
- X-rays travel in a straight line. These rays show reflection, refraction, interference, diffraction and polarisation and are not deflected by electric and magnetic fields.
- Long exposure of X-rays is injurious to the human body.
- X-rays show the **photoelectric effect.**

Uses of X-Rays

- **In Medical Sciences** X-rays are used in surgery for the detection of fractures, diseased organs, foreign matter like bullets, stones, etc. They are used in treatment of cancer and in skin diseases.
- **In Engineering** X-rays are used in detecting faults, cracks, flaws and gas pockets in the finished metal products and in heavy metal sheets.
- **In Scientific Work** X-rays are used in studying crystal structure and complex molecules.
- **In Custom Department** X-rays are used in custom department for detection of banned materials kept hidden

Radioactivity

- Radioactivity was discovered by **Henry Becquerel, Madame Curie** and **Pierre Curie** for which they jointly won the Nobel Prize.

- The nucleus having protons 83 or more are unstable. They emit α β, and γ particles and become stable. The elements of such nuclei are called radioactive elements and the phenomenon of emission of α β, and γ particles is called radioactivity.
- **Robert Pierre** and his wife **Madame Curie** discovered a new radioactive element, radium.
- The end product of all natural radioactive elements after emission of radioactive rays is lead.
- With the emission of an α-particle, atomic number is decreased by 2 and mass number is decreased by 4.
- With the emission of a β-particle, atomic number is increased by 1 and mass number does not change.

Nuclear Fission

- The nuclear reaction, in which a heavy nucleus splits into two nuclei of nearly equal mass is nuclear fission.

$$_{92}U^{235} + {}_{o}n^{1} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + {}_{30}n^{1} + \text{energy}$$

- **Atom Bomb** is based on nuclear fission. U 235 and Pu 239 are used as fissionable material.
- Nuclear fission was first demonstrated by **Hatin** and **Fritz Strassmann.**

Nuclear Fusion

- When two or more light nuclei combine together to form a heavier nucleus is called nuclear fusion.
- For the nuclear fusion, a temperature of the order of **10^8 K** is required

- **The Hydrogen Bomb** was made by the American Scientist in 1952. This is based on nuclear fusion. It is 1000 times more powerful than atom bomb

Nuclear Reactor or Atomic Pile

- Nuclear reactor is an arrangement in which a controlled nuclear fission reaction takes place.

- First nuclear reactor was established in Chicago University under the supervision of Prof Enrico Fermi.

- Heavy water, graphite and beryllium oxide are used to slow down the fast moving neutrons. They are called moderators.

- The cold water, liquid oxygen, etc. are used as coolant to remove heat generated.

- Cadmium or boron rods are good absorbers of neutrons and called the control rods.

Uses of Nuclear Reactor

i. To produce electrical energy from the energy released during fission.

ii. To produce different isotopes, which can be used in medical, physical and agriculture science

There are several components of nuclear reactor which are as follows:

- Fissionable Fuel U^{235} or U^{239} is used.
- Moderator Moderator decreases the energy of neutrons, so that they can be further used for fission reaction. Heavy water and graphite are used as moderators.
- Control Rod Rods of cadmium or boron are used to absorb the excess neutrons produced in fission of uranium nucleus, so that the chain reaction continues to be controlled.
- Coolant A large amount of heat is produced during fission. Coolant absorbs that heat and prevents excessive rise in the temperature. The coolant may be water, heavy water or a gas like He or CO^2 .

LASER (Light Amplification by Stimulated Emission of Radiation)

It is a device that produces an intense, coherent and highly directional beam of the single frequency. It can be transmitted over a great distance without being spread.

LASER Technology in India

In 1964, the first laser as Gallium Arsenide (GaA) semi-conductor laser was designed and fabricated by Bhabha Atomic Research Centre (BARC).

Various Institutions such as CAT (Centre for Advanced Technology), DRDO (Defence Research and Development Organisation) and Indian Institute of Science (IISc) work on laser plasma, quantum optics, etc., are going to work with American collaboration. **MASER** (Microwave Amplification by Stimulated Emission of Radiation) It was invented by three American scientists **Gordon, Gieyer** and **H Townes** in 1952. It uses microwaves in amplified form of longer wavelengths of light, while ordinary lasers use light.

Units of Measurement

Quantity	Unit (SI)	Quantity	Unit (SI)
Length	Metre	Viscosity	Newton.sec/m^2
Time	Second	Surface tension	Newton/metre
Mass	Kilogram	Heat	Joule
Area	Square metre	Temperature	Kelvin
Volume	Cubic metre	Absolute temperature	Kelvin
Velocity	Metre/second	Resistance	Ohm
Acceleration	Metre/second2	Electric current	Ampere
Density	Kilogram/metre 3	Electromotive force	Volt
Momentum	Kilogram-metre/second	Electrical conductivity	mho/metre
Work	Joule	Electric energy	Kilowatt-hour
Energy	Joule	Electric power	Kilowatt or watt
Force	Newton	Magnetic intensity	Oersted
Pressure	Pascal or Newton/metre 2	Charge	Coulomb
Frequency	Hertz	Magnetic induction	Gauss
Power	Watt	Luminous flux	Candela
Weight	Newton or Kilogram	Intensity of sound	Decibel
Impulse	Newton-second	Power of lens	Dioptre
Angular velocity	Radian /second	Depth of sea	Fathom