THE UNIVERSE

The universe is commonly defined as the totality of everything that exists including all physical matter and energy, the planets, stars, galaxies and the contents of intergalactic space

Big

- Theories of the universe form a discipline known as cosmology.
- Einstein was the first truly modern cosmologist.
- An evolving universe was first discussed in the 1920s by **Aleksandr Fried Mann, Georges Lemaitre** and others.

Pulsating Theory

- The total mass of the universe is more them a certain value the expansion stopped by the gravitational pull. Then the universe may again contract.
- At Present the Universe is expanding

Steady State Theory

- The Steady State theory (also known as the infinite Universe theory of continuous creation) is a model developed in 1948 **by Fred Hoyle, Thomas Gold and Hermann Bondy** and others as an alternative to the Big Bang theory.
- In steady state views, new matter is continuously created as the universe was expands.

Measuring Distances In Astronomy

- Light year is the distance that light travels in a year. Since light travels at 3 Lakhs kilometres a second,
- It goes about 9.467×10^{15} m in a year.

Astronomical Objects: In 1924, Edwin Hubble first demonstrated existence of galaxies beyond Milk Way.

Galaxies

- Galaxies are giant assemblies of stars, gases, and dust into which most of the visible matter in the universe is concentrated.
- The majority of the galaxies close enough to be observed in any detail can be divided into three broad categories elliptical, spiral and irregular.
- The nearest outside galaxies to our own (the Milky Way) are the large and small clouds of Magellan (about 100,000 light years distant from us). Another well-known galaxy is Andromeda, the largest of the nearby galaxies.

The Milky Way

- It is the giant star system to which the sun belongs. The Galaxy has a spiral structure and, like other spiral galaxies, is highly flattened.
- The diameter of the galactic disc is 100,000 light years and the sun is situated at a distance of 27,000 light years from the centre.

The Galactic Year :

The galactic year also known as a cosmic year is the duration of time required for the solar system to orbit once around the centre of the milky way galaxy. Estimates of the length of orbit range from 225 to 250 million terrestrial years.

Nebula

- A nebula is a cloud of interstellar gas and dust that can be observed either as a luminous patch of light "a bright nebula" or as "a dark hole or band against a brighter background" a dark nebula.

Stars

- A star is a celestial body, consisting of a large, self-luminous mass of hot gases held together by its own gravity.
- The composition by weight of an average star is about 70% hydrogen, 28% helium, 1.5% carbon, nitrogen, neon 0.5 iron group and heavier elements.
- The star contains by far the largest fraction of the mass of the

Sun spots are the magnetic storms on the surface of the sun.

universe. Stars are born, produce nuclear energy, evolve, and eventually die.

- ❖ The smallest stars are only about one-tenth the size of the sun.
- ❖ The largest are several hundred times larger. They look small only because they are far away.

Clusters

- ❖ Groups of star held by mutual gravitational force in the galaxy are called star clusters.
- ❖ A group of 100 to 1000 stars is called galactic cluster.
- ❖ A group of about 10,000 stars is called globular cluster.

1. Dwarf:

- ❖ If the original mass of the star is less than about 2 solar masses we get a dense white dwarf or less than 1.2 solar mass.
- ❖ As there is no nuclear fuel left in the white drawf it just cools off slowly changing its colour from white to yellow, to red and finally becomes a dark body.

2. Neutron Star:

- ❖ If the original mass of the star was between 2 and 5 solar masses, the back kick of the supernova explosion will compress the core of the star to nuclear densities giving rise to a neutron star.
- ❖ The mass of a neutron star is less than 2 solar masses and its radius is about 10 kilometres. Neutron stars have large magnetic fields. If the magnetic axis is inclined to the axis of rotation, the star emits pulses at regular intervals, the periods of which range from 30 milli seconds to 3 seconds. These are pulsars the first of which was discovered by the radio astronomers in 1967.

3. Black Hole:

- ❖ If the original mass of the star was more than 5 solar masses, the back kick of the supernova explosion is so violent that the core continues to contract indefinitely, giving rise to a black hole.
- ❖ As the contraction proceeds, the radius decreases continuously and acceleration due to gravity g, at the surface goes on increasing.

- Finally a stage comes when the g value is so large that even the photon cannot escape from the surface of the body.

Constellation:

- On a clear night, here and there groups of stars seem to form special shapes. Such a group or shape is called a constellation.

The Solar System

- The solar system is a group of celestial bodies comprising the sun and the large number of bodies that are bound gravitationally to the sun and revolve around it.
- The latter include the planets, asteroids, comets etc.
- Various theories were given to explain the origin of the solar system

Sun

- The sun is the star at the centre of the solar system.

No	Hypothesis	Pro pounder
1.	Gaseous hypothesis	Kant
2.	Nebular hypothesis	Laplace
3.	Planetesimal hypothesis	Chamber line and Moultan
4.	Tidal hypothesis	Sir James jeans and Harold Jeffreys
5.	Binary star Hypothesis	HN Russell
6.	Supernova Hypothesis	F Hoyte
7.	Inter stellar dust hypothesis	Otto schmidt
8.	Electromagnetic hypothesis	HAIFVEN
9.	Protoplanet hypothesis	G kuiper
10.	Nebular cloud hypothesis	Dr.Von Weisacker

- It is the nearest star to the earth. As a star it is a rather ordinary one, of average size. Many other stars are bigger, heavier, hotter and brighter.
- The next nearest star, Alpha Centauri,

SUN

Diameter	:	1,392,000km
Volume	:	1,304,000 times, Earth's;
Gravitational Pull	:	28 x Earth's
Relative Density	:	1.4 kg/m^3
Temperature	:	6000°C at surface and 15,000,000°C at the centre

- The sun atmosphere
  1. Photosphere - 14 x 10^6k
  2. Chromosphere - 6000k

- Sun Produces energy by fusion
  Two sets of Fusion reactions (hydrogen into helium)
  1. Proton Proton Chain
  2. CN cycles (minor amount to the energy) Four hydrogen nuclei combine to a helium nucleus. This mass difference converted to energy.
     ($E = mc^2$) This energy which keeps the sun shining.

PLANETS

- A planet is a heavenly body that orbits the sun or another star and shines only by the light it reflects.

The Terrestrial Planets:

- Next to the Sun, the most important members of the solar system are the planets.
- Of the nine planets, the nearest four to the Sun namely Mercury, Venus, Earth and Mars are called the terrestrial planets because their structure is similar to the earth.
- The common features of these planets are:
  1. a thin rocky crust,
  2. a mantle rich in iron and magnesium and
  3. a core of molten metal's.
- The terrestrial planets have very few moons. These planets have thin atmospheres.

The Jovian Planets:

- The planets outside the orbit of Mars are much farther off than the terrestrial planets.
- The planets outside the orbit of Mars are called Jovian planets because their structure is similar to that of Jupiter.

- These are all gaseous bodies. They have ring systems around them and have large number of moons.

MERCURY

- Mercury is the inner most and smallest planet in the solar system orbiting the sun once every 87.969 Earth days.
- It is nearly of the same size as the moon and is much smaller compared to the earth with an equatorial radius of 2,439.7 km.
- The Mercury usually becomes visible in September and October just before sunrise in the eastern sky as a morning star.
- Mercury too has no atmosphere and its surface is rocky and mountainous too.

VENUS

- Venus or Shukra is the second planet in terms of its distance from the sun orbiting it every 224.7 Earth days.
- It is a planet, which our elders often called an evening or a morning star.

Important Facts

Biggest planet	Jupiter
Biggest satellite	Gannymede
Blue Planet	Earth
Green planet	Uranus
Brightest planet	Venus
Brightest star	Sirius (Dog star)
Closest star of solar system	Alpha centauri
Coldest planet	Neptune
Evening star	Venus
Farthest planet from sun	Neptune
Planet with maximum number of satellites	Jupiter
Fastest revolution in solar system	Mercury
Hottest planet	Venus

- The mass of the atmosphere of Venus is 96.5% co_2, with of the remaining 3.5% being nitrogen. Venus has no moon or satellite of its own.

THE EARTH

- Earth is the third planet in term of distance from the sun.

MARS

- The next planet in terms of distance from the sun is the Mars or Mongol. It appears reddish and therefore it is also called the red planet.

Important Facts

Importance	Planet
Den sect planet	Earth
Fastest rotation in solar system	Jupiter
Moring star	Venus
Nearest planet to earth	Venus
Nearest planet to sun	Mercury
Red planet	Mars
Slowest revolution in solar system	Neptune
Slowest rotation in solar system	Venus
Smallest planet	Mercury
Smallest satellite	Deimos
Earth's twin	Venus
Only satellite with an atmosphere like earth	Titan

JUPITER

- Jupiter is the largest of all the planets.
- Its mass is more than the combined mass of all other planets.

SATURN (SHANI)

- Saturn is the most distant planet known to the early astronomers. Its distance from the sun is almost two times that of Jupiter.
- Saturn is its beautiful rings that encircle the planet.
- There are three distinct rings that surround the planet.
- These rings are not visible with the naked eyes and can be observed only with the help of a telescope.

URANUS

- Uranus was the first planet to be discovered with the help of a telescope.
- William Herchel discovered the planet in 1781.
- Hydrogen and methane have been detected in the atmosphere of Uranus.

NEPTUNE

- Neptune is the eighth planet in terms of its distance from the sun. This is the second planet that was discovered with the help of telescope.

Albedo :

- ❖ The ratio of the amount of solar energy reflected by planet to that incident in it is known as albedo.
- ❖ The Albedo of Earth - 0.37.
- ❖ The Albedo of Venus is 85. Its reflects 85% light. So its contain high density atmosphere.
- ❖ Mercury albedo is 6%. So it not contain atmosphere.

- ❖ There are two factors which determine whether the planets have atmosphere or not,
  - i. acceleration due to gravity on it surface
  - ii. the surface temperature of the planet.
- ❖ The value of g for moon is very small (1/6th of the earth).
- ❖ Mercury has larger value of g than moon. There is no atmosphere because its very close to the sun and it temperature is high.

Escape speed of earth is 11.2 km/s

The escape speed is ve $= \sqrt{2gR}$

Mercury	= 4 km/s
Jupiter	= 60 km/s
moon	= 2.5 km/s
Sun	=620 km/s

(Escape speed very high)

Kepler's laws

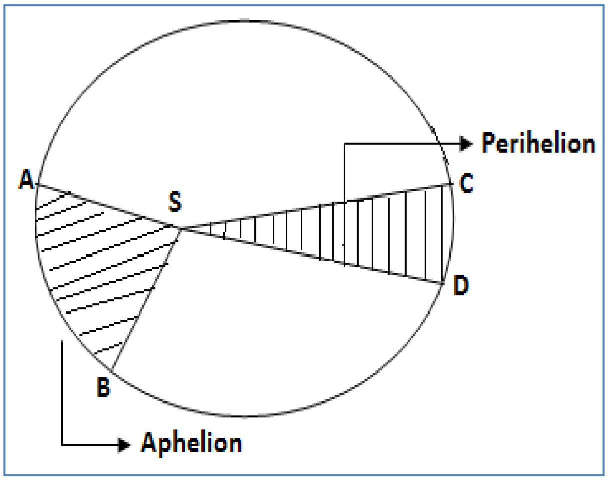
Motion of the planets around the sun Johannes Kepler (1571 – 1630) obtained the following three laws known as Kepler's Laws).

Law - I : the planets revolve around the sun in the elliptical orbits with sun at one of the focus.

Law - II : The radius vector sweeps out equal area in equal interval of time. This law may be derived from law of conservation of angular momentum.

The Kinetic energy of the planet is maximum when it is closest to the sun.

Law - III: The square of the period of revolution of a planet around the sun is directly proportional to the cube of the



mean distance between the planet and the sun.

$$T^2 \propto r^3$$

T – Planet revolution time

R – Mean distance between the planet and sun.

Asteroids

- Asteroids or minor planets circle in a broad belt between the orbits of Mars and Jupiter.
- They are chunks of rock covered in frozen gases. The largest is ceres.
- Today more than one thousand of these small bodies have been discovered and it is estimated that there are more than 50,000 in all. The orbits of some extend beyond the Mars-Jupiter space.

Comets

- A comet is a member of the solar system that travels around the sun in an orbit that generally is much more eccentric than the orbits of planets.
- Typical comets have three parts: the nucleus, coma, and comet tail.
- A comet cannot move in a circle.
- Thus, all periodic comets must move in ellipses.
- The comets approaches the sun, it is heated by the sun radiant energy vapourises and forms a leaf of about 10,000 km in diameter. The comets also develops a tail pointing away from the sun. Halley's comets is a Periodic comet which made its appearance in 1910 and in 1986. It would appear again in 2062 years.

Meteors and Meteorites

- The comets break into pieces as they approach very close to the sun. When the earths orbits cross the orbit of comet these broken pieces fall on the earth, Most of the pieces are burnt. They are called shooting stars. (Meteors)
- Some bigger size fully not burnt this called Meteorites.

GENERAL SCIENTIFIC LAWS

1. **Universal Gravitation (1666)**
- ❖ Isaac Newton came to the conclusion that all objects in the universe, from apples to planets, exert gravitational attraction on each other.

2. **Laws of Motion (1687)**
- ❖ The relationship between an object's mass (m), its acceleration (a) and the applied force (F) is F = ma.
- ❖ For every action there is an equal and opposite reaction.

3. **Electromagnetism (1807 -1873)**
- ❖ Pioneering experiments uncover the relationship between electricity and magnetism and lead to a set of equations that express the basic laws governing them.
- ❖ One of those experiments unexpectedly yield results in a classroom. In 1820
- ❖ Danish physicist Hans Christian Oersted was delivery his speach to the students about the possibility that electricity and magnetism are related. During the lecture, an experiment demonstrated the velocity of his theory in front of the whole class.

4. **Special Relativity (1905)**
- ❖ Albert Einstein overthrew basic assumptions about time and space by describing how clocks tick slower and distances appear to stretch as objects approach the speed of light.

5. **E = mc² (1905)**
- ❖ Albert Einstein's famous formula proves that mass and energy are different manifestations of the same thing, and that a very small amount of mass can be converted into a very large amount of energy.
- ❖ One profound implication of his discovery is that no object with mass can ever go faster the speed of light

6. **Quantum Leap (1900 -1935)**
- ❖ To describe the behaviour of subatomic particles, a new set of

natural law was developed by Max Planck, Albert Einstein, Werner Heisenberg and Erwin Schrodinger.

- ❖ A quantum leap is defined as the change of an electron within an atom from one energy state to another. This change happens at once, not gradually.

7. Nature of Light (1704 - 1905)

- ❖ Thought and experimentation by Isaac Newton, Thomas young and Albert Einstein lead to an understanding of what light is, how it behaves and how it is transmitted.
- ❖ Newton used a prism to split white light into its constituent colours and another prism to mix the colours into white light, proving at coloured light mixed together makes white light.
- ❖ Young established that light is a wave and that wavelength determines colour.
- ❖ Finally, Einstein recognized that light always travels at a constant speed, no matter what is the speed of the measure.

Superconductors (1911-1986)

- ❖ The unexpected discovery that some materials have no resistance to the flow of electricity promises to revolutionize industry and technology.
- ❖ Superconductivity occurs in a wide variety of materials, including simple elements like tin and aluminium, various metallic alloys and certain ceramic compounds.

8. Quarks (1962)

- ❖ Murray Gell-Mann proposed the existence of fundamental particles that combine to form composite objects such as protons and neutrons.
- ❖ A quark has both an electric and a "strong" charge. Protons and neutrons each contain three quarks.

9. Nuclear Forces (1666-1957)

- ❖ Discoveries of the basic forces at work on the subatomic level lead to the realization that all interactions in the universe are the result of four fundamental forces of nature-the strong and weak nuclear forces, the electromagnetic force and gravitation.

SCIENTIFIC INSTRUMENTS

Air Cooler	**An apparatus for cooling the air. Here air is blown through water and atmosphere cooled.**
Altimeter	An instrument used in aircrafts for measuring altitudes
Ammeter	An instrument used for measuring electric current.
Anemometer	An instrument to measure the speed and pressure of the wind.
Audiometer	It measures intensity of sound
Beaufort scale	It is used to measure wind force.
Barograph:	An instrument which registers automatically the altitude reached by an aeroplane.
Barometer	An instrument to measure atmospheric conditions and changes.
Binocular	It is used to view distance objects
Callipers	A compass with legs for measuring the inside or outside diameter of bodies.
Calorimeter	An instrument used for measuring quantities of heat.
Carburettor	An apparatus for charging air with petrol vapours in an internal combustion engine
Cinematograph	An apparatus for projecting pictures on the screen in so rapid a succession that picture seems to be in motion.
Cresco graph	An instrument for recording electrically the response of living matter to various kinds of stimuli.
Cardiograph	Is a medical instrument for tracing heart movements.

Chronometer	Is a clock to determine longitude of a vessel at sea.
Cyclotron	It is an apparatus for smashing atoms.
Computers	These are data-processing machines, which provide the information according to the requirements
Dictaphone	A trade name for a tape recorder.
Dynamo	A machine used for transforming mechanical energy into electrical energy.
Dynamometer	It measures electrical powers
Electric Motor	Machine for using electricity as a motive power.
Electrometer	An instrument for measuring electrical potential differences.
Epidiascope	For projecting films as well as images of opaque articles on a screen
Eudiometer	It is a glass tube for measuring volumes changes in the chemical reactions between gases.
Endoscope	It examines internal parts of the body
Fathometer	Is an instrument used for measuring depth of the ocean-
Gramophone	A machine for reproducing recorded sound
Hydrophone	An instrument for measuring the density of liquids with that of water,
hygrometer	An apparatus for measuring the humidity of air.
Internal Combustion Engine	An engine in which heat energy added the air within the working cylinder and converted into mechanical work through the medium of a piston or by a turbine rotator
Lactometer	A typical hygrometer for testing pure milk.
Laser	A device to throw a thin beam of light that is carried over great distances.

Water Meter	For measuring gallons of water consumed.
Volta meter	For measuring electricity consumed.
Magneto	A part of the motor car that converts mechanical energy into electrical energy.
Manometer	For determining the pressure of a gas
Micrometer	An instrument for measuring distance of angles
Microphone	An instrument which intensifies and renders audibly the faintest possible sound
Microscope	An optical instrument for producing greatly magnified images of very small objects.
Odometer	It is an instrument by which the distance covered by wheeled vehicles is measured
Periscope	Optical instrument used in trench warfare and in submarines for enabling an observer to see surrounding objects from a lower level.
Phonograph	Is an instrument used for reproducing sound
Photometer	Is an apparatus used to compare the illuminating power of two sources of light.
Pipette	It is a glass tube with the aid of which a definite volume of liquid may be transferred.
Pyrometer	Is an instrument for measuring high temperatures.
Radar	An instrument to detect the presence of enemy aircraft, submarine, etc., and also to determine its direction, distance and speed.
Radiogram	A combined radio and gramophone
Refract meter	It is an instrument to measure refractive indices

Radiometer	An instrument for measuring the radiant energy of light and heat.
Samaphore	System of signalling between two places generally ships
Seismometer	It is an apparatus for measuring the origin of earthquakes.
Sextant	An instrument for measuring angle
Spark Plug	Device for producing an electric spark to set off combustion in the cylinder of a petrol engine.
Stethoscope	A doctor's tool to listen to the beat of the heart
Stereoscope	A binocular optical instrument through which a double Photograph taken from two slightly different angles by two lenses cameras is viewed.
Speedometer	An instrument which registers the speed of the vehicle
Telephone	A device by virtue of which two persons at two different places can communicate. It consists of two main parts (i) a microphone and (ii) a receiver.
Telstar	It is a space communication satellite developed by Bell for overseas communications. It was launched on July 10, 1962 from Cape Kennedy (U.S.A.). Telstar, in addition to telephone calls, enables television microwave transmissions to be made from and to any country with a receiving and transmitting station.
Telemeter	Is an apparatus for recording physical events happening at a distance
Theodolite	An instrument for use in land surveying for measuring vertical and horizontal angles.
Thermometer	It is an instrument to measure the temperature.
Thermionic	Used in wireless telegraphy and radio broadcasting.

valve	
Thermostat	It is an instrument which controls temperature automatically. It is used in refrigerators, air- conditioners, geysers etc.
Transformer	It is an electric apparatus which is used to convert high voltage to low and vice versa.
Tachometer	An instrument for measuring the speed of aeroplanes, motors, etc.
Television	It is the transmission of images of moving objects by radio waves.
Telescope	An instrument designed to view the distant object easily.
Tele printer	An instrument which prints automatically messages sent from one place to another on telegraph lines.
Viscometer	Is an instrument to measure viscosity.
Voltmeter	It is an instrument to measure the potential difference across two points of an electrical circuit.
Volta meter	It is an apparatus for producing electrolysis in liquids
Wattmeter	Is an instrument for the direct measurement of power in watt of an electrical circuit.

INVENTIONS AND DISCOVERIES

DISCOVERIES		
c500	BC Static electricity	Thales of Miletus, Greece
c240	BC How things float	Archimedes, Greece
c150	Earth-centred universe	Claudius Ptolemy, Greece
1304	Cause of rainbow	Nicolaus Copernicus, Poland
1600	Earth's magnetism	William Gilbert, England
1604	How objects fall	Galileo Galilei, Italy
1609	How the planets move	Johannes Kepler, Germany
1609	Moons of Jupiter	Galileo Galiei, Italy
1616	Chemical element defined	Robert Boyle, Ireland
1643	Air Pressure	Evangelista Torricelli, Italy
1662	Law of gases	Robert Boyle, Ireland
1666	Nature of white light	Isaac Newton, England
1666	Gravity	Isaac Newton, England
1687	Laws of motion	Isaac Newton, England
1690	Wave theory of light	Christian Huygens, Holland
1718	Fahrenheit temperature scale	Gabriel Fahrenheit, Germany
1742	Centigrade temperature scale	Anders Celsius, Sweden
1752	The nature of lightning	Benjamin Franklin, USA
1772	Nature of Combustion	Antonie Lavoisier, France
1774	Preparation of Oxygen	Joseph Priestley, England
1791	Metric system of Units	France
1798	Nature of heat	Count Rumford, England

1800	Wave nature of light	Thomas Young, England
1800	Electric current	Alessandro Volta, Italy
1802	Atomic theory	John Dalton, England
1807	Discovery of new	Humphry Davy, elements using electricity England
1808	How gases combine	Joseph Gay-Lussac, France
1811	Molecules in gases	Amedeo Avogadro, Italy
1820	Electromagnetism	Hans Oersted, Denmark
1820	Force between current carrying	
	wires	Andre Ampere, France
1827	Law of electric current	George Ohm, Germany
1831	Electromagnetic induction	Michael Faraday, England
1833	Laws of Electrolysis	Michael Faraday, England
1841	Heat and work	James Joule, England
1855	Prediction of radio-waves	James Maxwell, Scotland
1869	Periodic table of elements	Dimitri Mendelev USSR
1887	Radio waves discovered	Heinrich Hertz, Germany
1887	Speed of light	Albert Michelson, USA
1894	Noble gases	William Ramsey, Scotland
1895	X-rays	Wilhelm Rontgen, Germany
1896	Radioactivity	Antoine Becquerel" France
1897	Electron	Joseph John Thomson, England
1898	Radium	Pierre and Marie Curie, France
1899	Alpha and Beta particles	Ernest Rutherford, New Zealand
1900	Quantum theory	Max Planck, Germany

1903	Theory of radioactivity	Ernest Rutherford (New Zealand) and Frederick Soddy (England)
1905	Relativity	Albert Einstein, Germany
1905	Photoelectric effect	Albert Einstein, Germany
1911	Atomic nucleus	Ernest Rutherford, New Zealand
1911	Superconductors	Heike Kammerlingh Onnes, Holland
1913	Structure of the atom	Niels Bohr, Denmark
1915	General relativity	Albert Einstein, Germany
1919	Proton Ernest	Rutherford, New Zealand
1926	Wave nature of matter	Erwin Schroedinger, Austria
1927	Uncertainty principle	Werner Heisenberg, Germany
1929	Expanding universe	Edwin Hubble, USA
1932	Neutron	James Chadwick, England
1938	Nuclear Fission	Otto Hahn, Germany
1939	Chemical bonding	Linus Pauling. USA
1964	Quark	Murray Gell-Mann, USA
1974	Black hole	Stephen Hawking, England
1984	Polymerase chain	Kary Mullis reaction
1986	High-temperature superconductors	Alex Muller (Switzerland) and George Bednorz (West Germany)
INVENTIONS		
c4000 BC	Wheel	Asia
c4000 BC	Weighing instruments	Mesopotamia
c3500 BC	Potters wheel	Mesopotamia
236 BC	Screw for lifting water	Archimedes,Greece
600 BC	Cast iron	China

c1000	Gunpowder	China
1088	Water-powered clock	Han Kung-Lien, China
1267	Magnifying glass	Roger Bacon, England
1280	Spectacles	Sadi Popozo, Italy
c1450	Printing Press	Johannes Gutenberg, Germany
c1590	Microscope	Zacharias Janseen, Holland
c1593	Thermometer	Galileo Galilei, Italy
c1608	Lens telescope	Hans Lippershey, Holland
1642	Adding machine	Blaise Pascal, France
1643	Mercury barometer	Evangelista Torricelli, Italy
1657	Pendulum clock	Christiaan Huygens, Holland
1668	Reflecting telescope	Issac Newton, England
1674	Calculating machine	Gottfried von Leibniz. Germany
1698	Steam engine	Thomas Savery, England
1764	Spinning machine	James Hargreaves, Eng and
1712	Steam-driven pump	Thomas Newcomen, England
1733	Mechanical loom	John Kay,England
1752	Lightening conductor	Benjamin Franklin, USA
1769	Efficient steam engine	James Watt, England
1769	Steam-driven carriage	Nicolas Cugnot, France
1775	Submarine	David Bushnell, USA
1786	Steam boat	John Fitch USA
1783	Hot-air Balloon	Etienne and Joseph Montgolfier, France
1800	Electric battery	Alessandro Volta, Italy
1803	Steam train	Richard Trevithick, England
1820	Electromagnet	Hans Oersted, Denmark
1822	Photograph	Josephe Niepce, France

1831	Transformer	Michael Faraday, England
1831	Dynamo	Michael Faraday, England
1831	Electric motor	Michael Faraday, England
1835	Photographic negative	William Fox Talbot, England
1837	Electric telegraph	William Cooke and Charles Wheatstone (England)
1838	Morse code	Samuel Morse, USA
1839	Bicycle	Kirkpatrick Macmillan, Scotland
1843	Aneroid barometer	Lucien Vidi, France
1843	Iron-pulled ship	Isambard Brunei,
1843	Analytical engine	Charles Babbage, England
1852	Steam-powered airship	Henri Giffard, France
1856	Steel furnace	Henry Bessemer, England
1856	Synthetic dyes	William Perkin, England
1859	Spectroscope	Gutav Kirchoff and Robert Bunsen, Germany
1860	Gas-burning engine	Etienne Lenoir, Belgium
1862	Plastics	Alexander Parkes, England
1866	Dry cell battery	Georges Leclanche, France
1867	Dynamite	Alfred Nobel, Sweden
1876	Telephone	Alexander Graham Bell, USA
1876	Four-stroke gas engine	Nikolaus Otto
1877	Phonograph	Thomas Edison, USA
1879	Electric Light	Thomas Edison, USA
1879	Refrigerator	Karl Von Linde, Germany
1882	Sewing machine	Waiter Hunt, USA
1883	Petrol engine	Gottlieb Daimler, Germany
1884	Steam turbine	Charles Parsons, England

1885	Motorcycle	Gottlieb Daimler, Germany
1885	Motor car	Karl Benz, Germany
1888	Pneumatic cycle tyre	John Dunlop, Scotland
1889	Telephone exchange	Almon Strowger, USA
1891	Moving pictures	Thomas Edison, USA
1891	Electrical storage-battery	Gaston Plant, France
1892	Oil-burning engine	Rudolf Diesel, Germany
1894	Radio transmitter	Guglielmo Marconi, Italy
1897	Cathode-ray tube	Ferdinand Braun, Germany
1898	Tape recorder	Valdemar Poulsen, Denmark
1900	Hydrofoil boat	E. Forlanini, Italy
1903	Aeroplane	Wilbur and Orville Wright, USA
1904	Diode valve	John Ambrose Fleming, England
1907	Helicopter	Paul Cornu, France
1908	Geiger counter	Hans Geiger, Germany
1918	Sonar	Paul Lengevin, France
1925	Television	John Logie Baird, Scotland
1926	Liquid-fuelled rocket	Robert Goddard, USA
1930	Jet engine	Frank Whittle, England
1931	Electron microscope	Max Knoll and Ernst Ruska, Germany
1931	Cyclotron	Ernest Lawrence, USA
1935	Nylon	Wallace Carothers, USA
1935	Radar	Robert Watson-Watt, England
1937	Radio telescope	Grote Reber, USA
1938	Scanning electron	M.Von Ardenne, Germany microscope
1942	Nuclear reactor	Enrico Fermi, USA

1947	Transistor	John Bardeen, Wiliam Schokley and Waiter Brattain, USA
1947	Instant Camera	Edwin Land, USA
1948	Computer	Fredric Williams and Tom Kilburn, England
1948	Hologram	Denis Gabor, Hungary
1949	Rotary engine	Felix Wankel, Germany
1954	Communication satellite	Arthur Clarke, England
1955	Ultrasound scanning	I. Donald, England
1956	Video recorder	A. Poniatoff, USA
1957	First artificial satellite	USSR
1958	Integrated circuit	Jack Kilby, USA
1960	Laser	Theodore Maiman, USA
1961	First man in space	Yuri Gagarin, USSR
1962	First communication satellite launched	USA
1966	Optical fibres	K. Kao and G.Hockham, England
1969	First men on Moon	Neil Armstrong and Edwin Aldrin, USA
1971	Microprocessor	Ted Hoff, USA
1971	First space station	USSR
1981	Space Shuttle	USA
1980	Hepatitis B	Baruch
	Vaccine invented	Blumberg (USA)
1981	MS-DOS invented 1st IBM-PC invented scanning tunneling microscope	Tim Paterson and Gary Kindall (USA) Gred Karl Binning and Heinrich Rohrer
1985	Windows Program	Microsoft USA

1991	WWW (World Wide Web)	Tim Berner Lee
2001	iPod Self contained artificial Heart	Tony Fadell (USA) Alain F. Carpentier,
2005	You Tube - The online Video Sharing Community	Steve Chen, Chad and Jawed Karim
2008	Large Hadron Colloider	CERN French-Swiss border

NOBEL PRIZE IN PHYSICS

Year 2016

1. David J. Thouless
2. F. Duncan M. Haldane
3. John. M. Kosterlitz

- For theoretical discoveries of topological phase transitions and topological phase of matter.

Year 2015

1. Takaaki kajita
2. Arthuv B. Mc Donald

- For the discovery of neutrino oscillations, which shows that neutrinos have mass.

Year 2014

1. Isamu Akasaki
2. Hiroshi Amano Shuji Nakamuva

- For the invention of efficient blue light – emitting diodes which has enabled bright and energy saving white light sources.

Year 2013

1. Francois Englert, Perter W.Higgs

- For the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles and which recently was confirmed through the discovery of the ATLAS and CMS experiments at CERN's large Hadron collider.

Year 2012

1. Serge Haroche, David J. Wineland

- For ground breaking experimented methods that enable measuring and manipulation of individual quantum systems.

Year 2011

1. Saul Perlmutter, Brian P. Schmidt, Adam G.Riess

- For the discovery of the accelerating expansion of the universe through observation of distant supernovae.

Neutrino oscillation : It is a quantum mechanical phenomenon where by a neutrino created with a specific lepton flavour (electron Muon, or tau) can later be measured to have a different flavour.

FAMOUS SCIENTISTS AND THEIR CONTRIBUTIONS		
Names	**Major Contributions/Discoveries**	**Country of Origin**
Isaac Newton	Universal Law of gravitation; Laws of Motion; Reflecting Telescope	U.K.
Galileo Galilei	Law of inertia	Italy
Archimedes	Principle of Buoyancy; Principle of the lever	Greece
James Clerk Maxwell	Electromagnetic theory; Light-and electromagnetic wave	U.K.
W.K. Roentgen	X-rays	Germany
Marie Sklodowska Curie	Discovery of Radium and Polonium; Studies on natural radioactivity	Poland

Albert Einstein	Law of Photoelectricity; Theory of Relativity	Germany
S.N. Bose	Quantum Statistics	India
James Chadwick	Neutron	U.K.
Niels Bohr	Quantum Model of Hydrogen atom	Denmark
Earnest Rutherford	Nuclear model of atom	Denmark
C.V. Raman	Inelastic scattering of light by molecules	India
Christian Huygens	Wave theory of light	Holland
Michael Faraday	Laws of Electromagnetic Induction	U.K.
Edwin Hubble	Expanding Universe	U.S.A.
Homi Jehangir Bhabha	Cascade process in cosmic radiation	India
Abdus Salam	Unification of weak and electromagnetic interactions	Pakistan
RA Millikan	Measurement of electronic charge	U.S.A.
Earnest Orlando Lawrence	Cyclotron	U.S.A.
Wolfgang Pauli	Quantum Exclusion Principles	Austria
Louis victor de Broglie	Wave nature of matter	France
J.J. Thomson	Electron	U.K.
S. Chandrasekhar	Chandrasekhar limit, structure and evolution of stars	India
Lev Davidovich Landau	Theory of Condensed Matter; Liquid Helium	Russia
Heinrich Rudolf Hertz	Electromagnetic waves	Germany

J.c. Bose	Ultra short radio waves	India
Hideki Yukawa	Theory of Nuclear Forces	Japan
Werner Heisenberg	Quantum Mechanics; Uncertainty Principle	Germany
Victor Francis Hess	Cosmic Radiation	Austria
M.N. Saha	Thermal Ionization	India
G.N. Ramachandran	Triple Helical Structure of Proteins	India

LINK BETWEEN TECHNOLOGY AND PHYSICS	
Technologies	**Scientific Principle(s)**
Steam engine	Laws of Thermodynamics
Nuclear reactor	Nuclear fission
Radio and Television	Propagation of electromagnetic waves
Computers	Digital logic
lasers	Light amplification by stimulated emission of radiation (population inversion)
Production of ultra high magnetic fields	Superconductivity
Rocket propulsion	Newton's (2nd and 3rd) laws of motion
Electric generator	Faraday's laws of electromagnetic induction
Hydroelectric power	Conversion of gravitational potential energy into electrical energy
Aeroplane	Bernoulli's principle in fluid dynamics
Particle accelerators	Motion of charged particles in electromagnetic

	fields
SONAR	Reflection of ultrasonic waves

FUNDAMENTAL FORCES OF NATURE			
Forces	**Relative Strength**	**Ranges**	**Operates Among**
Gravitational force	10^{-38}	Infinite	All objects in the universe (Gravitation)
Weak nuclear force	10^{-13}	Very short, within nuclear size (~10^{-15} m)	Bosons
Electromagnetic force	10^{-2}	Infinite	Photons
Strong nuclear force	1	Very short, within nuclear size (~10^{-15} m)	Mesons

ATOMIC INDUSTRIAL ORGANISATION	
Heavy water board (HWB)	Mumbai
Nuclear fuel complex (NFC)	Hyderabad
Board of radiation & isotope technology (BRIT)	Mumbai

ATOMIC PUBLIC SECTORS	
Nuclear power corporation of India limited (NPCIL)	Mumbai
Uranium corporation of India Limited (UCIL)	Jharkhand
Indian rare earth limited (IRE)	Mumbai
Electronics corporation of India limited (ECIL)	Hyderabad

AUTONOMOUS NATIONAL INSTITUTES	
Tata institute of fundamental institute (TIFR)	Mumbai
Tata memorial centre (TMC)	Mumbai
Saha institute of Nuclear physics (SINP)	Kolkata
Institute of physics (IOP)	Bhubaneshwar
Harish Chandra research institute (HRI)	Allahabad
Institute of Mathematical sciences (IMSs)	Chennai
Institute for plasma research (IPR)	Ahmedabad

NATIONAL SCIENTIFIC LABORATORIES

LIGO	- INDIGO, Lab located in Hingoli Maharashtra
LIGO	- The laser interferometer gravitational wave observatory
INDIGO	- Indian initiative in gravitational wave observation
Neutrino	- Lab
(INO) India	- Based Neutrino observatory
	- Pottipuram in Bodi, Theni District, Tamilnadu.

Central building research Institute	Roorkee
Central Drug research Institute	Lucknow
Central Electro – chemical research institute	Karaikaudi (TN)
Central Electronics Engineering research institute	Pilani (Rajasthan)
Central food technological research institute	Mysore
Central fuel research institute	Dhanbad (Jharkhand)
Central glass and ceramic research institute	Kolkata
Central institute of medical and aromatic plants	Lucknow
Central leather research institute	Chennai
Central Mining research station	Dhanbad (jharhand)
Central salt & marine chemical research institute	Bhavnagar (Gujarat)
Central scientific instrument organisation	Chandigrah
Indian Institute of petroleum	Dehradun

Industrial toxicology research centre	Lucknow
National Botanical research institute	Lucknow
National Biological laboratory	Palampur (HP)
National Environment engineering institute	Nagpur
National Geophysical research institute	Hyderabad
National institute of oceanography	Panaji (Goa)
National metallurgical Laboratory	Jamshedpur
National physical laboratory	New Delhi
Pulsars research laboratory	Pachmarthi (MP)

ATOMIC RESEARCH CENTRES

Bhabha atomic research centre (BARC)	Mumbai - 1957
Indira Gandhi centre for atomic research (IGCAR)	Kalpakkam - 1971
Centre for advanced technology (CAT)	Indore - 1984
Variable energy cyclotron centre (VECC)	Kolkata - 1977
Atomic minerals directorate (AMD)	Hyderabad -

ATOMIC SERVICES ORGANISATION

Directors of purchase and stores (DPS)	Mumbai
Construction services and estate management group (CS& EMG)	Mumbai
General services organisation (GSO)	Tamil Nadu
Atomic energy education society (AEES)	Mumbai

NUCLEAR POWER STATIONS

Tarapur	Maharashtra	1969	Two boiling water reactor (BWR)
Rawatbhata	Rajasthan	1973	Pressured heavy water reactors (PHWR)
Kalpakkam	TamilNadu	1984	Pressured heavy water reactors (PHWR)
Narora	Uttar Pradesh	1991	Pressured heavy water reactors (PHWR)
Kakrapar	Gujarat	1993	Pressured heavy water reactors (PHWR)
Kaiga	Karnataka	2007	Pressured heavy water reactors (PHWR)

HEAVY WATER PRODUCTION

Nangal	Punjab
Baroda	Gujarat
Talcher	Orissa
Tuticorin	Tamil Nadu
Thal	Maharashtra
Hazira	Gujarat
Rawatbhata	Rajasthan
Manuguru	Andhra Pradesh

SPACE PROGRAMME

Vikramsarabhai space centre (VSSC)	Thiruvananthapuram
ISRO satellite centre (ISAC)	Bangalore
Space applications centre (SAC)	Ahmedabad
Sriharikota space centre (SSC)	Andhra Pradesh

Liquid propulsion systems centre (LPSC)	Thiruvanathapuram,Bangalore, Mahendragiri (Tamil Nadu)
Development and Education communication unit (DECU)	Ahmedabad
ISRO telemetry tracking and command network (ISTRAC)	Bangalore
Master Control facility	Karnataka
ISRO inertial system unit (IISU)	Thiruvananthapuram
Physical research laboratory (PRL)	Ahmedabad
National remote sensing agency (NRSA)	Hyderabad
The national mesosphere stratosphere troposphere radar facility (NMRF)	Gadanki
Laboratory for electro optics systems (LEOS)	Bangalore
Region remote sensing service centres (RRSSC)	Bangalore
North eastern space applications Center (Ne – Sac)	Meghalaya
Semic conductor laboratory (SCL)	Chandigarph
The Indian institute of space science and technology (IIST)	Thiruvananthapuram

SCIENCE & TECHNOLOGY

Agharkar research institute	Pune
Birbalshahni institute of Palaebotany	Lucknow
Bose institute	Kolkata
Centre for cellular and molecular biology	Hyderbad
Central arid zone research institute	Jodhpur (Rajasthan)

Central coconut research station	Kasergod(Kerala)
Central glass and ceramic research institute	New Delhi
Central inland fisheries research station	Barrackpore (WB)
Central institute of fisheries technology	Erankulam (Kerala)
Central jute technological research institute	Kolkata
Central marine research station	Chennai
Central rice research laboratory	Chepuk, Chennai
Central rice research institute	Cuttack (Orissa)
Central Tobacco research station	Rajamundry (AP)
Centre for DNA fingerprinting and diagnostics	Hyderabad
Centre for liquid crystal research	Bangalore
Dr. B.R. Ambedkar national Institute of technology	Jalandhur
High altitude research laboratory	Gulmarg (Kashmir)
Indian academy of sciences	Bangalore
Indian agriculture research institute	New Delhi
Indian cancer research centre	Mumbai
Indian institute of astrophysics	Bangalore
Indian institute of geomagnetism	Mumbai
Indian institute of sugar technology	Kanpur (UP)
Indian institute of Tropical Meteorology	Pune
Indian Lac research Institute	Ranchi
Indian National academy of engineering	New Delhi
Indian National centre for ocean and information services	Hyderabad

Indian national science Academy	New Delhi
Institute of Bio resources and sustainable development	Imphal
Institute of life sciences	Bhubaneswar
Institute of Microbial technology	Hyderabad
Jawaharlal Nehru centre for advanced scientific research	Bangalore
Malaviya national institute of technology	Jaipur
Maulanaazad national institute of technology	Bhopal
Motilal Nehru national institute of technology	Allahabad
National Brain research centre	Manesar
National centre for Antarctic and ocean research	Goa
National centre for cell sciences	Pune
National centre for plant genome research	New Delhi
National dairy research institute	Karnal (Haryana)
National environment engineering research institute	Nagpur (Maharashtra)
National institute of immunology	New Delhi
National institute of ocean technology	Chennai
National seismological database centre	New Delhi
National sugar research institute	Kanpur (UP)
Physical research laboratory	Ahmedabad
Raman research institute	Bangalore
S.V. national institute of technology	Surat
S.N. Bose national centre for basic science	Kolkatta
Seismic research centre	Bangalore

Shirchitratirunal institute for medical S & T	Thiruvananthapuram
The centre for maine living resource & ecology	Kochi
The national centre for biological science	Bangalore
The survey training institute	Hyderabad
Wadia institute of Himalayan Geology	Dehradum

GLOSSARY

- **Absolute Zero:** The lowest imaginable temperature, at which all the particles in a body would be completely at rest. It is 273°C (-459°F).
- **Acoustics:** The science that studies sound and hearing.
- **Alpha Particle:** One of the three types of radiations emitted by some radioactive substances, consisting of two protons and two neutrons.
- **Ampere:** The unit used to measure the size of an electric current. It is named after the French scientist Andre Ampere (1775-1836).
- **Amplifier**: An electronic device that increases (amplifies) the strength of electric currents. Radio and TV sets and record players all use amplifier.
- **Amplitude:** The maximum value (or maximum height of the waves) of anything that goes back and forth in a cycle, for example alternating current or sound waves.
- **Anode:** The positive terminal through which electric current goes into a liquid (called the electrolyte) during electrolysis.
- **Asteroid:** Another name for a minor planet-one of the thousands of small bodies circling around the Sun, measuring from a few metres to a thousand kilometres.
- **Atmosphere :** The envelope of gases that surrounds the Earth (or any other planet, star or moon).
- **Aurora** : A display of coloured light high in the Earth's atmosphere. It is caused when particles from the Sun make the gas in the atmosphere glow. This usually happens near the Earth's poles. There are two kinds of aurora.
  1. Aurora Borealis visible in the northern hemisphere.
  2. Aurora Austral is visible in the southern hemisphere.
- **Barometer** : An instrument used for measuring atmospheric or air pressure. In the Mercury

Barometer, the height of a column of mercury indicates the pressure. In an Aneroid Barometer, the pressure is measured by the amount it squashes the sides of a metal box containing a vacuum.

- **Beta Particles:** Fast-moving electrons emitted by some radioactive substances, more penetrating than alpha particles, but less penetrating than gamma rays.
- **Big Bang:** The theory most astronomers use to explain how the universe began. Everything that exists now was crushed into a super hot ball that exploded about 4.7 billion years ago.
- **Binary Star:** A pair of stars turning around each other. They may take a few hours if they are very close, or thousands of years if they are far apart.
- **Black Hole** : An object with such strong gravity that light waves cannot escape from it. Anything pulled inside a black hole is lost forever.
- **Cathode :** The negative terminal through which electric current goes into a liquid (called the electrolyte) during electrolysis.
- **Cathode Ray Tube:** An electronic device basically consisting of a glass tube containing a vacuum and two metal electrodes-a negative cathode and a positive anode. When the electrodes are connected to a high voltage source of electricity, electrons stream from the cathode to the anode. Using suitable deflecting devices, the electrons can be aimed at a fluorescent screen on the wall of the glass tube. This glows when struck by electrons.
- **Centrifugal Force**: An outward force that acts on an object turning in a circle around a central point.
- **Centripetal Force:** The inward force that keeps a body, such as a satellite, moving in a circular path.
- **Chronometer:** A device for measuring time, such as a clock or a watch.
- **Comet:** A mixture of crumbly rock and ice, a few kilometres across, which travels around the Sun. If it comes near the Sun the heat makes dust and gas pour off in a long glowing 'tail':

- **Computer:** An electronic device for storing and manipulating large amounts of information. Their great advantage is the speed with which they do calculations and retrieve information.
- **Concave:** Curved inwards. A concave lens is thicker at the edges than in the middle.
- **Conduction:** The process of passing heat from molecule to molecule that allows heat to be transferred from one part of a substance to another.
- **Conductor:** A substance, such as copper, that will allow electricity to flow along it.
- **Constellation:** A group of stars making a pattern in the sky. Some constellations were named thousands of years ago. There are 88 covering the whole sky.
- **Convection:** The movement of heat from place to place in a flowing liquid or gas.
- **Convex:** Curved outwards. A convex lens is thinner at the edges than in the middle.
- **Corona:** The outer part of the Sun's atmosphere that is visible as a pearly halo during a total eclipse of the Sun.
- **Current Electricity**: The movement of electrons along a conductor that produces a flow of electricity.
- **Decibel:** A unit used for measuring the loudness of sounds. A soft whisper is about 0 decibels. A jet taking off is about 120 decibels.
- **Diffraction of Light :** The way a thin beam of light spreads out around the edge of a shadow. This causes thin bands of light and dark along the edges of the shadow.
- **Diode:** An electronic tube containing two electrodes, one an anode, the other a cathode and allowing current to go in one direction only.
- **Direct Current**: An electric current that flows in one direction only. The current from a battery is a direct current (DC).
- **Doppler effect:** The effect takes place in light and sound.. Doppler effect in light takes place when stars recedes or move towards the surface of earth. Doppler effect in sound takes place when there is a

relative motion between the source and the observer or both.

- **Elasticity:** The ability of a material to return to its original shape after it has been stretched out of shape.
- **Electricity:** Energy associated with a flow of electrons or other charged particles.
- **Electrode :** An electrical conductor through which an electric current leaves or enters an electron tube or similar device. Anodes and cathodes are electrodes.
- **Electromagnet:** A device consisting of many coils of wire through which electric current can flow. When the current is turned on there is a magnetic field. It vanishes when the current is turned off.
- **Electromagnetic wave:** When a charged particle is accelerated, it produces a magnetic field in the near space, the magnetic field acts as a virtual source for the further production of electric field. Hence both of them acts as source for each other. This phenomenon gives rise to electromagnetic waves.
- **Electron** : Sub-atomic particle with a negative electric charge.
- **Electronics:** The study of devices such as diodes or valves where electrons pass through a semiconductor, gas or vacuum as in computers, radios or televisions.
- **Electron Microscope:** A microscope that magnifies with the help of streams of electrons instead of light rays.
- **Electron Tube:** A tube controlling a flow of electrons, for instance a diode, triode or a television tube.
- **Evaporation:** The gradual turning of a liquid into a vapour (gas). When wet clothes dry out, the water in them evaporates. Fahrenheit Temperature Scales. A scale used to measure temperatures in which the freezing point of water is 320 and the boiling point of water is 212°. The scale is named after the German Scientist Gabriel Daniel Fahrenheit (1686 - 1736).
- **Fluorescence**: The glow caused when light is absorbed at one wavelength and sent out at another. In a neon-tube, ultraviolet is turned' into visible light by fluorescent substances in the tube.
- **Force:** A push or pull that makes an object move, or change shape or

direction. Examples are gravity and magnetism.

- **Frequency:** The number of waves or cycles that occur in one second. A frequency of one Hertz is one cycle per second. Frequency of sound waves determines their pitch, frequency of light waves determines their colour.
- **Free Fall:** An object that is moving under the influence of gravity alone is said to be in 'free fall' A spacecraft is in free fall when its rocket engine is not firing. Everything in it is then weightless, because everything is moving together - sensations of weight occur only when the pull of gravity is resisted by for example, the ground.
- **Friction**: The force that holds back two surfaces that are sliding across one another. Bicycle brakes for example use friction to stop motion.
- **Fulcrum:** The point about which a lever turns or pivots.
- **Galaxy**: The name given to our own Milky Way or to a very remote, independent system of stars.
- **Galvanometer:** An instrument which detects and measures very small electric currents.
- **Gamma Rays:** A powerful type of electromagnetic radiation given out when certain atoms disintegrate.
- **Geiger Counter:** An instrument which detects and measures radio-activity. It is named after Hans Geiger {1882-1945}, the German Scientist who invented it.
- **Generator:** A machine that converts mechanical energy into electrical energy. A dynamo produces direct current (D.C) electricity. An alternator produces alternating current (A.C.) electricity.
- **Geo-stationary Orbit:** A satellite orbit that follows the line of the equator 35,900 km (22,307 miles) above the Earth's surface in the same direction in which the Earth spins. At this height the satellite moves at the same rate as the Earth spins and therefore always remains above the same point on the equator.
- **Gravity/Gravitation**: Every particle of matter attracts every other particle. This force is called gravity. The gravitational attraction of small objects is not noticeable, but the gravitational

attraction of a mountain can be measured. And gravitational force is responsible for preventing the oceans, atmosphere and everything else on Earth from escaping into Space.

- **Greenhouse Effect:** The result of solar energy being trapped in the Earth's atmosphere causing too much carbon-dioxide and raising average world temperatures.
- **Half-life**: The time it takes for the radio-active substance to decrease to half its original value.
- **Heat:** A form of energy due to the movement of the atoms and molecules in a body. The amount of heat in a body is usually measured in joules, although heat units like the calorie or the British thermal unit are sometimes used.
- **Hertz:** The unit used to measure frequency, equal to one cycle per second.
- **Hologram**: A three-dimensional picture made using laser light.
- **Hovercraft**: A propeller-driven vehicle which moves on a cushion of air. Hovercraft can also travel over land or sea.
- **Hydraulics:** The science of using liquids, such as water or oil, to operate mechanical devices. The word 'hydraulic' is applied to such devices. A car's main brakes, for example, are hydraulic. They are operated by the pressure of the driver's foot on a pedal, transmitted through oil contained in pipes.
- **Inertia:** Also known as Newton's 1^{st} law of motion i.e. a body remain in a state of rest or in a state of motion unless an external force is applied.

Information

- **Technology:** The methods of sending, obtaining, and storing information by electronic means. It involves the use of computers, data bases, and modems for connecting computers together.
- **Infra-red Radiation**: Heat radiation-a type of invisible light with wavelength longer than the wavelength of visible light. The infra-red radiation in sunlight can be felt as warmth on the skin.
- **Insulator:** Either a substance that will not allow heat to pass through it, or one that will not allow electricity to pass through it.

- **Interstellar:** All space outside the solar system among the stars. Integrated Circuit. A tiny mass of electronic components in or on a small slice of semiconductor substance.
- **Joule:** A unit used to measure the amount of energy or work done. One joule is the work done when a weight of one Newton is lifted one meter. It is named after James Joule (1818-89), a British physicist.
- **Kelvin Temperature Scale:** A scale used to measure temperatures in which absolute zero is 0° and the freezing point of water is 273.15°. It is named after the British scientist Lord Kelvin (1824-1907).
- **Kinetic Energy:** The energy an object has because it is motion.
- **Laser** : A device that produces a narrow powerful beam of light. A laser is a light amplifier that increases an initial weak pulse of light into an intense narrow beam. Lasers are used in medicine and industry.
- **LCD Display:** The kind of display used on most calculators and digital watches. It uses a thin layer of a 'liquid crystal', which is a little like a crystal and a little like a liquid. When an electric voltage is applied at any place on the liquid crystal that part of it becomes dark. That is how the constantly changing letters and numbers are made. 'LCD' stands for 'liquid crystal diode'.
- **Lever:** A simple machine used for lifting heavy weights. It consists of a strong bar that turns about a pivot, like a seesaw.
- **Lightning:** The result of water and air molecules in clouds rubbing together, making an electrical charge.
- **Light Year:** The distance that light travels in one year (=9,500,000,000,000 km or 6,000,000,000,000 miles).
- **Load:** The weight lifted or moved by a machine.
- **Magnet:** An object which attracts iron and attracts or repels other magnets. The magnetic force is strongest at two points called the north and south poles. When free to move, a magnet turns so that the north pole points north and the south pole points south, as in a compass.

- **Magnetic Field:** The space around a magnet or an electric current where its magnetic effect can be felt.
- **Mass:** The amount of matter in an object. Mass is different from weight because weight depends on gravity but mass is always the same.
- **Modem:** A device used to connect a computer to a telephone line so that computer information can be sent along the line. The modem changes the computer signals, which are called digital signals, into sounds that can be transmitted by telephone lines.
- **Momentum:** The impetus of a moving object. It is equal to the mass of the object multiplied by its speed.
- **Neutron:** One of the two types of particles that make up the atomic nucleus. It is so called because it is electrically neutral-it has no electric charge. Outside the nucleus a neutron survives 13 minutes on average then it breaks up into an electron and proton.
- **Nuclear Fission:** Fission is another word for splitting. In nuclear fission, the nucleus of an atom splits in two, releasing energy.
- **Nuclear Fusion:** The joining, or fusing, of the nuclei of two light atoms to make a heavier nucleus. This process releases large amount of energy. The sun produces its energy by fusing hydrogen nuclei to make helium.
- **Nuclear Reactor:** A power station producing electricity from energy released by splitting the nuclei of atoms.
- **Nucleus:** The central core of the atom. The simplest nucleus is that of the hydrogen atom. It consists of a single proton. All other nuclei consist of neutrons and protons. Electrons revolve around the nucleus. They are very light, and most of the atom's weight is in the-nucleus.
- **Nylon:** An artificial plastic and fibre. The raw materials come from oil or coal. Many different types of nylon are made, including nylon thread.
- **Ohm:** A unit used to measure electrical resistance. It is named after G.S. Ohm (1787 -1854). a German Physicist.
- **Orbit:** The invisible path which a planet follows around the sun, or a

satellite follows around a planet. Orbits are never perfect circles, but ellipses.

- **Ozone Layer:** A layer of the earth's atmosphere containing ozone, which protects the earth from too much ultra-violet radiation.
- **Parallel Circuit:** An electrical circuit in which the components are connected side-by-side. The current flowing in the circuit is shared by the components.
- **Particle Accelerator:** A large machine used by scientists to study the small particles that make up atoms. It speeds up, or accelerates, particles such as protons or electrons and shoots them at a target.
- **Penumbra:** The lighter edge of a shadow, where the bright object (such as the Sun) is not completely hidden. It is also the name for the lighter edge of a sunspot.
- **Phosphorescence:** A cold glow given out by some substances. For example, fireflies and glow-worms phosphors.
- **Photon:** A packet of light energy. In some situation, a beam of light behaves as if it was a stream of small particles which scientists call photons.
- **Photoelectric Effect:** The generation of an electric current in certain materials when light falls on them. Light meters in cameras use the photoelectric effect to measure the brightness of light.
- **Physical Change:** A change, such as melting or boiling, that does not produce a new chemical substance.
- **Physics:** The science that studies matter, the forces of nature and the different forms of energy, such as heat, light and motion.
- **Piezoelectric Effect:** The generation of an electric current in certain crystals when they are squeezed or stretched. When a voltage is applied to the same crystal it contracts (grows smaller) or expands (grows bigger) slightly. Piezoelectric crystals are used in watch and calculator bleepers.
- **Plastics:** Artificial material in which the molecules are joined together in a long chain (or polymer). They can be shaped by pressure and heat. Many types of plastic are made, with different

properties for different purposes.

- **Potential Energy:** The store of energy an object has because of its position. It can be converted to kinetic energy if the object begins to move.
- **Pressure:** The force or weight acting on a unit area of surface. Atmospheric pressure is the pressure of the air on a unit area of the earth's surface.
- **Primary Colours:** One of the three colours (red, green and blue) of light that, when mixed, can give light of any colour; or one of the three colours of pigment or paint (red, blue and yellow) that can be mixed to give paint of any colour, except white.
- **Pulsar:** A fast-spinning neutron star sending out a beam of light waves and radio waves. This beam 'pulses; like the circling beam of a lighthouse.
- **Quasars:** Giant galaxies with centres hundreds of times brighter than ordinary galaxies. They are all thousands of millions of light-years away.
- **Radar:** (Radio detection and ranging). A system that uses radio waves to detect the position of objects. The radio waves are sent out by a transmitter/receiver via a rotating aerial. The waves that are reflected by objects return to the aerial. In the receiver the distance and direction of each object is calculated using the time difference between sending and receiving the signal and the position of the aerial. An electrical signal containing this information is sent to a device that works rather like a television and the objects appear as luminous 'blips' on a screen.
- **Radiation (heat) :** The transfer of heat in the form of electromagnetic waves.
- **Radioactivity:** A radioactive element has unstable nuclei which split up and emit alpha, beta and gamma rays. When the nucleus of an atom splits up, it produces radiation in the form of rays or particles. Radiation in large doses is Lethal.
- **Radiocarbon dating:** Discussed by Sir Willard Libby. Also called carbon dating: a way of telling how

old dead matter is. All living things give off small amounts of radiation, this amount decreases after the thing dies and so can be measured to find how long ago it lived.

- **Reflection:** The bouncing back of a sound or light wave as it hits a surface.
- **Refraction:** The bending of a ray of light as it passes from one substance to another, for example, from glass to air.
- **Resistance:** The way in which an electrical circuit opposes the flow of electric current through it. Resistance is measured in ohms and is equal to the voltage divided by the current.
- **Resonance:** The way in which a small vibration can cause a large effect. For example, a singer can make a glass vibrate slightly by singing loudly, if the right note is sung, the glass vibrates violently because of resonance, and may break.
- **Robot:** Based on principle of artificial intelligence. A machine which can do a job that is usually done by a human being. Robots are used on factory assembly-lines to do one particular job that is continually repeated.
- **Satellite:** A body that revolves around a larger one because of its gravitational attraction. The Moon is a satellite of the earth, and the planets are satellites of the Sun.
- **Semiconductor:** Material that conducts electricity not as well as conductors such as copper, but better than insulators such as glass.
- **Series Circuit:** An electric circuit in which the components are connected end-to-end, so that the current flows through all the components one after the other.
- **Solar System:** The family of planets, moons and comets revolving around our sun. There are probably countless other solar systems around stars in our Galaxy and elsewhere in the Universe.
- **Solid:** A physical state of matter, in which a substance has a definite mass, volume and shape.
- **Solution:** A liquid that contains a solid (or gaseous) substance completely dissolved in it.
- **Spectroscope:** An instrument attached to a telescope used by

astronomers to produce a spectrum of a celestial body.

- **Spectrum:** The rainbow-coloured band of light produced when white light is passed through a prism. The colours are arranged in order of the wavelength of their waves; red is the longest and violet is the shortest.
- **Static Electricity:** Non-moving electric charge on an object, often produced by friction, for example shoes rubbing on a carpet.
- **Superconductor:** A substance which loses its electrical resistance at very low temperatures. Superconductors are usually metals. Researchers have recently discovered ceramic super conductors that do not require such extreme low temperatures.
- **Surface Tension:** The way the surface of a liquid such as water seems to be covered by a thin elastic film. This causes small droplets to become ball-shaped. Some insects can walk on water because the surface tension holds them up.
- **Thermodynamics:** The branch of science concerned with heat and mechanical energy, and how one can be converted into the other.
- **Transformer:** A device used to change the voltage of an alternating electric current. Transformers are used in electric power stations to increase the voltage of the electricity produced so that it can be sent along high-voltage cables.
- **Transistor:** An electronic device, with no moving parts, that can be used as a switch or to amplify an electric signal.
- **Triode:** An electron tube containing a cathode, an anode and grid to control the current between them.
- **Ultrasound:** Sound waves of very high frequency which are beyond human hearing.
- **Ultraviolet Radiation:** A type of invisible light with wavelength shorter than the wavelength of visible light. Ultraviolet light in sunshine causes suntan.
- **Universe:** The whole of space and everything in it.
- **Vacuum:** A space in which there are no atoms or molecules. (Perfect vacuums are impossible to make so it usually means a place where the pressure is much lower than that of normal air).

- **Volt:** It is the unit of measuring electric potential difference.
- **Voltaic Cell:** A type of electric cell invented by Alessandro Volta in 800. It consists of two terminal of different metals dipping into salt water.
- **Wavelength:** The distance between the peak of one wave and the pea k of the next.
- **Waves:** Regular disturbances that spread out from their source. Sound waves are disturbances of the molecules of the air caused by a vibrating body. Electromagnetic waves are disturbances of the magnetic and electric fields in space.
- **Weight** : It is the force exerted by gravity.
- **Work:** The amount of energy used when a force moves an object. The amount of work done is calculated by multiplying the force by the distance the object moves.
- **X-rays:** Very short electromagnetic waves which can cause a chemical change on photographic plates and are used in radiography by doctors.

MECHANICS & PROPERTIES OF MATTER

MECHANICS AND PROPERTIES OF MATTER

Elasticity

- The property of a material to regain its original state when the deforming force is removed is called elasticity

Stress and strain

- This restoring force per unit area of a deformed body is known as stress.

$$\text{Stress} = \frac{\text{Restoring Force}}{Area} = \frac{\text{Nm}^{-2}}{Area}$$

- Its dimensional formula is $ML^{-1}T^{-2}$.
- Strain produced in a body is defined as the ratio of change in dimension of a body to the original dimension.

$$\text{Strain} = \frac{\text{Change in Dimension}}{Original\ Dimension}$$

- Strain is the ratio of two similar quantities. Therefore it has no unit.

Elastic limit

- If an elastic material is stretched or compressed beyond a certain limit, it will not regain its original state and will remain deformed. The limit beyond which permanent deformation occurs is called the elastic limit.

Hooke's law

- Within the elastic limit, strain produced in a body is directly proportional to the stress that produces it. (i.e) stress α strain

$$\frac{\text{Stress}}{Strain} = \text{a constant}$$

Pascal's law

- Pascal's law states that if the effect of gravity can be neglected then the pressure in a fluid in equilibrium is the same everywhere.

Applications of Pascal's law

(i) Hydraulic lift

(ii) Hydraulic brake

Ball pen works on the principle of capillarity

Viscosity

❖ Viscosity is the property of the fluid by virtue of which it opposes relative motion between its different layers. Both liquids and gases exhibit viscosity but liquids are much more viscous than gases.

Co-efficient of viscosity

❖ The coefficient of viscosity of a liquid is numerically equal to the viscous force acting tangentially between two layers of liquid having unit area of contact and unit velocity gradient normal to the direction of flow of liquid.

❖ The unit of η is Ns m^{-2}. Its dimensional formula is $ML^{-1}T^{-1}$.

Streamline flow

❖ The flow of a liquid is said to be steady, streamline or laminar if every particle of the liquid follows exactly the path of its preceding particle and has the same velocity of its preceding particle at every point

Turbulent flow

❖ When the velocity of a liquid exceeds the critical velocity, the path and velocities of the liquid become disorderly. At this stage, the flow loses all its orderliness and is called turbulent flow.

Some examples of turbulent flow are:

1. After rising a short distance, the smooth column of smoke from an incense stick breaks up into irregular and random patterns.
2. The flash - flood after a heavy rain. Critical velocity of a liquid can be defined as that velocity of liquid upto which the flow is streamlined and above which its flow becomes turbulent.

Stoke's law (for highly viscous liquids)

1. Coefficient of viscosity η of the liquid depends on
2. Radius a of the sphere and
3. Velocity v of the spherical body.

Dimensionally it can be proved that

$$F = k\,\eta a v$$

Experimentally Stoke found that

$$k = 6\pi$$

$$\therefore F = 6\pi\,\eta a v$$

This is Stoke's law.

Application of Stoke's law

❖ **Falling of rain drops:** When the water drops are small in size, their terminal velocities are small. Therefore they remain suspended in air in the form of clouds. But as the drops combine and grow in size, their terminal velocities increase. Hence they start falling as rain.

Surface tension Intermolecular forces

❖ The force between two molecules of a substance is called intermolecular force.

❖ The intermolecular forces are of two types. They are (i) cohesive force and (ii) adhesive force.

(i) Cohesive force

❖ Cohesive force is the force of attraction between the molecules of the same substance. This cohesive force is very strong in solids, weak in liquids and extremely weak in gases.

(ii) Adhesive force

❖ Adhesive force is the force of attraction between the moelcules of two different substances.

❖ For example due to the adhesive force, ink sticks to paper while writing. Fevicol, gum etc exhibit strong adhesive property.

Surface tension of a liquid

❖ Surface tension is the property of the free surface of a liquid at rest to behave like a stretched membrane in order to acquire minimum surface area.

Capillarity

❖ The property of surface tension gives rise to an interesting phenomenon called capillarity The rise of a liquid in a capillary tube is known as capillarity

Illustrations of capillarity:

(i) A blotting paper absorbs ink by capillary action. The pores in the blotting paper act as capillaries.

(ii) The oil in a lamp rises up the wick through the narrow spaces between the threads of the wick.

(iii) A sponge retains water due to capillary action.

(iv) Walls get damped in rainy season due to absorption of water by bricks.

Factors affecting surface tension

Impurities present in a liquid appreciably affect surface tension. A highly soluble substance like salt increases the surface tension whereas sparingly soluble substances like soap decreases the surface tension. The surface tension decreases with rise in temperature. The temperature at which the surface tension of a liquid becomes zero is called critical temperature of the liquid.

Applications of surface tension

(i) During stormy weather, oil is poured into the sea around the ship. As the surface tension of oil is less than that of water, it spreads on water surface. Due to the decrease in surface tension, the velocity of the waves decreases. This reduces the wrath of the waves on the ship.

(ii) Lubricating oils spread easily to all parts because of their low surface tension. Detergent action is due to the reduction of surface tension of water when soap or detergent is added to water

(iii) Cotton dresses are preferred in summer because cotton dresses have fine pores which act as capillaries for the sweat.

Bernoulli's theorem

Streamline flow of a non-viscous and incompressible liquid, the sum of the pressure energy, kinetic energy and potential energy per unit mass is a constant.

$$\frac{P}{\rho} + \frac{V^2}{2} + gh = \text{constant}$$

This equation is known as Bernoulli's equation

Application of Bernoulli's theorem

(i) Lift of an aircraft wing
(ii) Blowing of roofs
(iii) Bunsen burner
(iv) Motion of two parallel boats

Liquids

Liquids flow from one place to another. They have a definite volume. They take the shape of the container. Liquids show very little change in volume even when large compressive forces are applied. So we assume that liquids are

Water drops are spherical because of its surface tension incompressible. Pressure at any point inside a liquid is P = hρg. This shows that pressure increases with depth.

When a body floats or immerses in a liquid, the pressure on the bottom surface is more than that the pressure on the top surface. Due to the difference in pressure, an upward force acts on the body. **This upward force is called upthrust or buoyant force.** The buoyant force is equal to the weight of the liquid displaced.

Archimedes Principle

When a body is immersed in fluid (liquid or gas) it experiences an apparent loss of weight which is equal to the weight of the fluid displaced.

Density

Density of a body is defined as the mass per unit volume of the body.

$$Density = \frac{Mass}{Volume}$$

Unit of density is Kg m^{-3}

Relative density (Specific gravity)

Relative density is defined as the ratio of density of the body to the density of water.

$$\text{Relative density} = \frac{\text{Density of the body}}{\text{Density of water}}$$

It has no unit.

Laws of floatation

1. The weight of the floating body is equal to the weight of the liquid displaced by it.
2. The centre of gravity of the floating body and the centre of gravity of the liquid displaced (centre of buoyancy) are in the same vertical line. A ship made up of iron floats in water. This is because the ship is hollow and contains air. The large space inside the ship enables it to displace a volume of water much greater than the actual volume of iron that was used in the construction. So the weight of water displaced is greater than the weight of the ship.

Know more:

❖ The density of air is 14 times greater than that of hydrogen. The weight of a hydrogen filled balloon is much less than the weight of the air it displaces. The

When common salt is mixed with ice, the melting point is lowered.

difference between the two weights gives the lifting power of the balloon. Thus a hydrogen filled balloon flies high in the air.

Know more:

- ❖ Submarines float on the surface of the water and can also submerge below the surface of the water. They have ballast tanks which can be filled with sea water when the submarine wants to submerge.
- ❖ When it wants to surface, the tanks are emptied by blowing compressed air.

Hydrometers

- ❖ The laws of floatation are made use of in the construction of hydrometers used for the determination of the relative densities of solids and liquids. There are two types of hydrometers.
- ❖ The constant immersion hydrometer, in which the weight of the hydrometer is adjusted to make it sink to the same fixed mark in all liquids.
- ❖ The variable immersion hydrometer in which the weight of the hydrometer remains the same, but the depth to which it sinks in different liquids vary A common hydrometer used to test the purity of milk by noting its specific gravity is called a LACTOMETER.

When ice melts its volume will decrease

PHYSICAL QUANTITIES, STANDARDS & UNITS

Units and Dimension & Errors

1. Review of Basic Concepts :

- Physics is the branch of Science which deals with observation, measurement and description of natural phenomena related to Matter and Energy 'Physics' is also defined as the study of nature and its law.
- Mechanics is one of the branches of Physics which deals with the studies of forces acting on the bodies.
- Physical Quantities are the quantities which can be able to describe the Laws of physics Physical quantities may be divided into fundamental and derived quantities.
- Fundamental quantities can be classified into 7 Quantities . Namely :
    - Mass
    - Length
    - Time
    - Temperature
    - Electric current
    - Luminous Intensity
    - Amount of substance
- In addition to these seven basic units there are two supplementary units – 'radian' and 'steradian'. The units of Fundamental quantities are called 'fundamental units'
- In 1960, to measure the physical quantities, International System of Units abbreviated as 'SI' in all languages was introduced.

<u>Supplementary units</u>

Name of Quantity	Name of Unit
Plane angle	Radian
Solid angle	Steradian

Fundamental Quantities can be defined as follows :

- The fundamental quantities should be independent to one another.
- All other quantities may be expressed in terms of fundamental quantities.

Derived Quantities and their units :

PHYSICAL QUANTITY	EXPRESSION	UNIT
Area	Length x breadth	m^2
Volume	area x height	m^3
Velocity	Displacement / time	ms^{-1}
Acceleration	Velocity / time	ms^{-2}
Angular velocity	Angular displacement/time	rad s^{-1}
Angular acceleration	Angular velocity/time	rad s^{-2}
Density	Mass/ volume	Kg m^{-3}
Momentum	Mass x velocity	Kg m s^{-1}
Moment of Inertia	Mass x $(distance)^2$	Kg m^2
Force	Mass x acceleration	$Kgms^{-2}$ or N
Pressure	Force x area	Nm^{-2} or Pa
Energy (work)	Force x distance	Nm or J
Impulse	Force x time	Ns
Surface tension	Force / length	Nm^{-1}
Moment of force (torque)	Force x distance	Nm
Electric change	Current x time	As
Current density	Current / area	Am^{-2}
Magnetic induction	Force/ [current x length]	NA^{-1} m^{-1}

Fundamental or Basic Quantities:

Quantity	Unit	Symbol	Dimension
Length	Metre	M	L
Mass	Kilogram	Kg	M
Time	Second	S	T
Electric current	Ampere	A	A
Temperature	Kelvin	K	K
Luminous Intensity	Candela	Cd	Cd
Amount of substance	Mole	Mol	Mol

❖ Dimension of a physical quantity are the powers to which the fundamental quantities must be raised.

Derived Quantities :

❖ The quantities derived from the fundamental quantities are called derived quantities.

Eg. Area, Volume, Density

Derived Units :

❖ The units of derived quantities are called derived units.

Rules and conventions for writing SI Units and their Symbols :

1. The units named after scientists are not written with a capital initial latter.

   E.g: Newton, Henry, watt.

2. The symbols of the units named after scientists should be written by a capital letter.

   E.g : N for Newton, H for Henry, W for watt

3. Small letters are used as symbols for units not derived from a proper name.

   E.g : m for metre, kg for kilogram

4. No full stop or other punctuation marks should be used within or at the end of symbols.

   E.g: 50 m and not as 50m

5. The symbols of the units do not take plural form.

   E.g: 10kg not as 10kgs

6. When temperature is expressed in Kelvin, the degree sign is omitted.

   E.g: 273 K not as 273°K

7. If expressed in Celsius scale, degree sign to be included.

   E.g: 100 °C not 100°C

8. Use of solidus is recommended only for indicating a division of one letter units symbol by another unit symbol. Not more than one solidus is used.

E.g: ms^{-1} or m/s J/K or JK^{-1} mol^{-1} but not J /K /mol

9. Some space is always to be left between the number and the symbol of the unit and also between the symbols for compound units such as force, momentum etc.

Nano second means one billionth of a second

10. Only accepted symbols should be used.

E.g: ampere is represented as A not as amp. (or) am; second is represented as ‘s’ and not as sec.

11. Numerical value of any physical quantity should be expressed of mercury is 1.36 x 104kg m^{-3} and not as 13600kg m^{-3}

E.g: density of mercury is 1.36 x 10 4 kg m^{-3} and not as 13600kg m^{-3}

Light Year:

In order to measure very large distance, the following units are used.

1. Light year
2. Astronomical Unit

Light year is the distance travelled by light in one year in vacuum.

Distance travelled = velocity of light x 1 year

∴ 1 light year = 3 x 10^8 m x 1 year (In seconds)

= 3 x 10^8 x 365.25 x 24 x 60 x 60

= 9.467x 10^{15}m

1 light year = 9.467 x 10^{15} m.

Greatest Units

- 1 light year = 9.46 x 10^{15} m
- 1 parsec = 3.84 x 10^{16} m
- 1 AU = 1.5 x 10^{11} m
- 1 metric ton = 10^3 kg
- 1 Quintal = 10^2 kg

Astronomical unit :

❖ Astronomical unit is the mean distance of the centre of the Sun from the centre of the earth. 1 Astronomical unit = 1.496 x 10^{11}m

Expressing Larger and smaller Quantities :

❖ The fundamental units are defined.

❖ Now it is easier to express larger and smaller units of the same physical quantity.

❖ The table lists the standard SI prefixes, their meanings and abbreviation.

Power of Ten	Prefix	Abbreviation
10^{-15}	femto	f
10^{-12}	Pico	p
10^{-9}	Nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centime	c

10^{-1}	deci	d
10^{1}	deca	da
10^{2}	Hecto	h
10^{3}	Kilo	k
10^{6}	Mega	M
10^{9}	Giga	G
10^{12}	Tera	T
10^{15}	Peta	P

Scalar Quantities

- Physical quantities which have magnitude only and no direction

  E.g : Mass, Speed, Volume, Work, Time, Power Energy

Vector Quantities

- Physical quantities which have magnitude and direction both and which obey triangle law.

  Eg : Displacement, Velocity, acceleration, force, Momentum

Dimensional Quantities :

- Constant which possess dimensions are called Dimensionless are called 'Dimensionless quantities'
  E.g : Strain, Specific Gravity etc.

Uses of Dimensional Analysis :

- The method of dimensional analysis is used in four important ways :

1. It is used to check the dimensional correctness of a given physical equation.
2. To the physical equation
3. Finding the dimensions of constants (or) variables in an equation.
4. Conversion of one unit from one system to another.

Limitation of Dimensional Analysis :

1. If a physical quantity depends more than 3 quantities, the dimensions cannot be applied
2. The dimensional method cannot be applied to equations involving exponential and trigonometric functions.
3. The value of dimensionless constants be determined by this method.

Dry ice is solid carbon dioxide

Dimensional Formulae of some derived quantities

PHYSICAL QUANTITY	EXPRESSION	DIMENSIONAL FORMULA
Area	length x breadth	$[L^{2}]$
Density	mass / volume	$[ML^{-3}]$
Acceleration	velocity / time	$[LT^{-2}]$
Momentum	mass x velocity	$[MLT^{-1-}]$
Force	mass x acceleration	$[MLT^{2}]$
Work	force x distance	$[ML^{2}T^{-2}]$
Power	work / time	$[ML^{2}T^{-3}]$
Energy	Work	$[ML^{2}T^{-2}]$
Impulse	force x time	$[MLT^{-1}]$
Radius of Gyration	distance	$[L]$
Pressure	force / area	$[ML^{-1}T^{-2}]$
Surface tension	force / length	$[MT^{-2}]$
Frequency	1 / time period	$[T^{-1}]$
Tension	force	$[MLT^{-2}]$
Moment of force (or torque]	force x distance	$[ML^{2}T^{-2}]$
Angular velocity	angular displacement / time	$[T^{-1}]$
Stress	force / area	$[ML^{-1}T^{-2}]$
Heat	energy	$[ML^{2}T^{2}]$
Heat capacity	heat energy / temperature	$[ML^{2}T^{2}K^{-1}]$
Charge	current x time	$[AT]$
Faraday constant	Avogadro constant x elementary charge	$[AT\ mol^{-1}]$
Magnetic induction	force / (current x length)	$[MT^{2}\ A^{-1}]$

Dimensional quantities

- Constants which possess dimensions are called dimensional constants. Planck's constant, universal gravitational constant are dimensional constants.
- Dimensional variables are those physical quantities which possess dimensions but do not have a fixed value. Example – velocity, force, etc.

Dimensionless quantities

- There are certain quantities which do not possess dimensions. They are called dimensionless quantities. Examples are strain, angle, specific gravity, etc. They are dimensionless as they are the ratio of two quantities having the same dimensional formula.

Fundamental Physical Constants	
Avagadro's number	N = 6.022045 X 10^{23} molecules/mol
Boltzmann's constant	k = R/N = 1.380662 x 10^{-23}J/K
Electric permittivity of evacuated free space	ε_0 = 8.85418782 x 10^{-12} F /m or C^2 J^{-1} m^{-1}
Electron charge mass ratio	e/m_e = 1.7588047 x 10^{11} C/kg
Elementary charge	e = 1.6021892 x 10^{-19} C
Faraday constant	F = Ne = 9.648456 x 10^4 C/mole
Gravitational constant,	G = 6.672 X 10^{-11} N.m^2/kg^2
Magnetic permeability	μ_0 = 4π X 10^{-7} H/m -12.5663706 x 10^{-7} Wb/ A.m.
Normal acceleration due to gravity	g = 9.80665 m/s^2 = 9.81 m/s^2
Normal atmospheric pressure	P = 1.0129 X 10^5 N/m^2
One Atomic mass unit	1 a.m.u. = 1.6605655 x 10^{-27} kg
Planck's constant	h = 6.622176 X 10^{-34} j.s.
Rest mass of electron	m_e = 9.109534 x 10^{-31} kg

Rest mass of neutron	M_n = 1.6749543 x 10^{-27} kg
Rest mass of proton	m_p = 1.6726485 x 10^{-27} kg
Rydberg constant	$R_\propto$ = 1.094 x $10^7 10^{-1}$
Solar constant	= 1.388 x 10^3 Wm^2
Stefan- Boltzmann constant	σ = 5.67032 X 10^{-8} Wm^{-2}. k^{-4}
Universal gas constant	R = 8.31 J/mole/K
Velocity of light in vacuum	C = 2.9979258 X 10^8 m/s = 3 x10^8 m/s
Volume of one mole of ideal gas at NTP	V = 22.41383 X 10^{-3} m^3/mole
Volume of one mole of ideal gas at NTP	= 0.00289782 m.k.

Least count of a venier callipers is 0.1 mm (or) 0.01 cm

FORCE, MOTION & ENERGY WORK

Motion

- Mechanics is one of the oldest branches of physics. It deals with the study of particles or bodies when they are at rest or in motion. Modern research and development in the spacecraft design, its automatic control, engine performance, electrical machines are highly dependent upon the basic principles of mechanics. Mechanics can be divided into statics and dynamics.
- Statics is the study of objects at rest; this requires the idea of forces in equilibrium.
- Dynamics is the study of moving objects. It comes from the Greek word dynamis which means power. Dynamics is further subdivided into kinematics and kinetics.
- Kinematics is the study of the relationship between displacement, velocity, acceleration and time of a given motion, without considering the forces that cause the motion.
- Kinetics deals with the relationship between the motion of bodies and forces acting on them.

Particle

- A particle is ideally just a piece or a quantity of matter, having practically no linear dimensions but only a position.

Rest and Motion

- When a body does not change its position with respect to time, then it is said to be at rest. Motion is the change of position of an object with respect to time. To study the motion of the object, one has to study the change in position (x,y,z coordinates) of the object with respect to the surroundings.
- It may be noted that the position of the object changes even due to the change in one, two or all the three coordinates of the position of the objects with respect to

time. Thus motion can be classified into three types :

(i) Motion in one dimension

Motion of an object is said to be one dimensional, if only one of the three coordinates specifying the position of the object changes with respect to time.

Example : An ant moving in a straight line, running athlete, etc.

(ii) Motion in two dimensions

In this type, the motion is represented by any two of the three coordinates.

Example : A body moving in a plane.

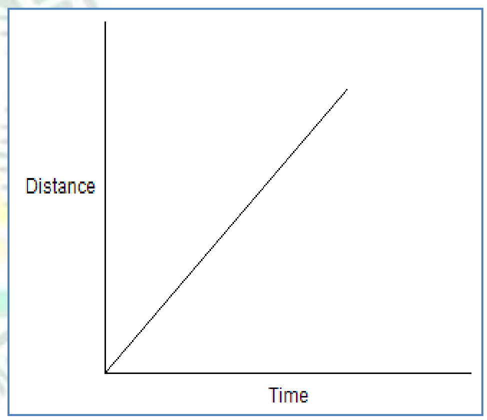
(iii) Motion in three dimensions

Motion of a body is said to be three dimensional, if all the three coordinates of the position of the body change with respect to time.

Examples : Motion of a flying bird, motion of a kite in the sky, motion of a molecule, etc.

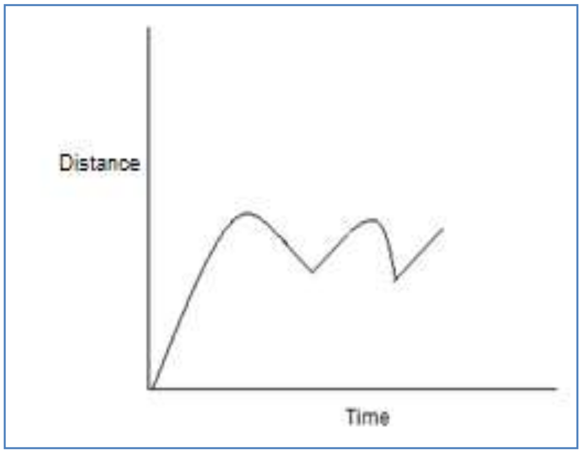
Motion in one dimension (rectilinear motion)

- The motion along a straight line is known as rectilinear motion. The important parameters required to study the motion along a straight line are position, displacement, velocity, and acceleration.
- If an object covers equal distances in equal intervals of time, it is said to be in **uniform motion.**



- If an object covers unequal distance in equal intervals of time, it is said to be in **non-uniform motion.**
- Speed is the quantity used to say whether the motion is slow or fast.

Water in a lake and nearby wells seeks the same level because force of gravity



Displacement

- The shortest distance or distance travelled along a straight line is known as displacement.

Difference between Distance and Displacement

	Distance	Displacement
1.	Distance is the length of the actual path followed by an object or body while moving from one point to another.	Shortest distance between two points
2.	Scalar quantity	Vector quantity
3.	Measured in metre in the SI system	Measured in metre in the SI system
4.	Not a unique quantity	Unique
5.	Distance can either be equal to or greater than displacement	Displacement is either equal to or less than the distance.

Speed

Speed is the distance travelled in one second (or) rate of distance travelled.

$$Speed = \frac{\textbf{Total Distance Travelled}}{\textbf{Time Taken}}$$

Speed is measured in m/s (or) ms^{-1}

Velocity

- Velocity is the displacement made in one second (or) rate of change of displacement. Rate of change means change per second.

$$\text{Velocity} = \frac{\textbf{Displacement}}{\textbf{Time}}$$

Difference Between Speed and Velocity

	Speed	Velocity
1.	Change of distance with respect to time	Change of displacement with respect to time
2.	Scalar Quantity	Vector Quantity
3.	Measured in m/s in the S.I. System	Measured in m/s in the S.I. System
4.	Positive Quantity	Positive can Negative Quantity

Uniform Velocity

If equal displacements are made by a body in equal intervals of time, then the body has uniform velocity

Acceleration

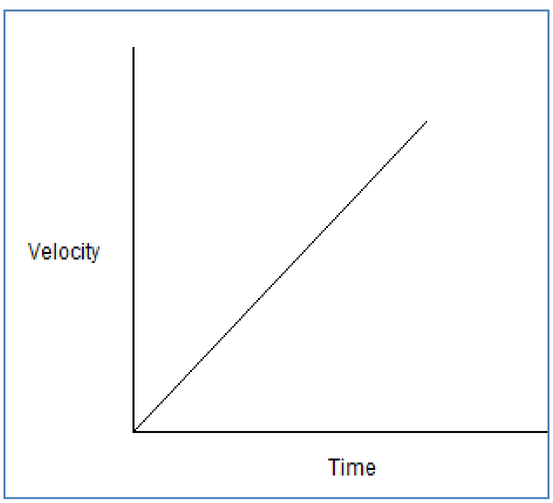
Acceleration is the change in velocity of an object per second or rate of change of velocity.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

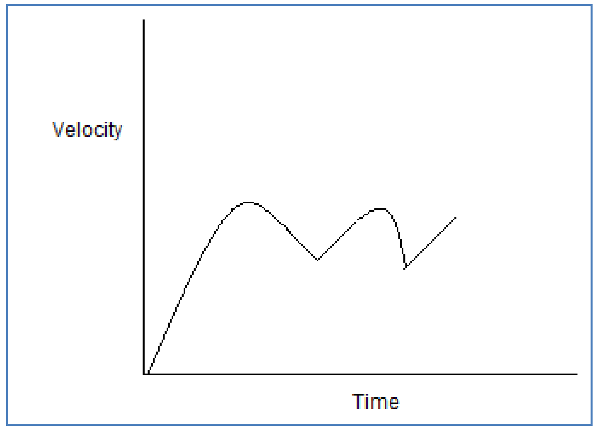
The unit of acceleration is m/s^2 or ms^{-2}

Uniform Acceleration

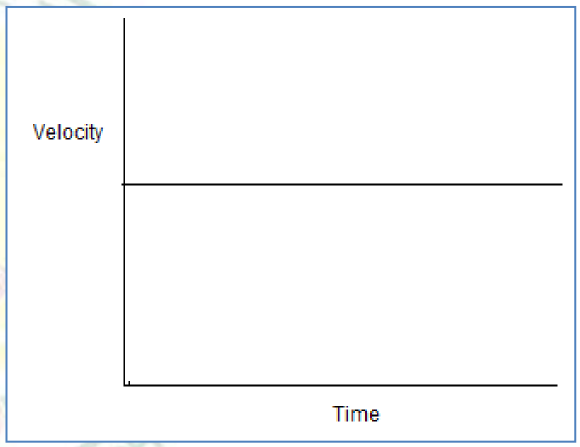
If an object travels in a straight line and its velocity increases or decreases by equal amount in equal intervals of time, then the acceleration of the object is uniform Uniformly accelerated motion.



Non-uniformly accelerated motion



Un - Accelerated Motion



Equation of motion

- $v = u + at$
- $s = ut + \frac{1}{2} at^2$
- $v^2 = u^2 + 2as$
- u - initial velocity
- v = final velocity
- t - time
- a - acceleration
- s - displacement

Body thrown upwards

Equations can be obtained by substituting

$a = -g$ and $s = h$

we get,

$$v = u - gt$$
$$h = ut - \frac{1}{2} gt^2$$
$$v^2 = u^2 - 2gh$$

For the freely falling body

$u = 0$, $a = g$ and $s = h$

Now, the equations will be

$$v = gt$$
$$h = \frac{1}{2} gt^2$$
$$v^2 = 2gh$$

Uniform circular Motion

- An athlete runs along the circumference of a circular path. This type of motion.

Angular displacement

- It is the angle covered by the line joining the body and the centre of the circle (radius vector) when it moves from one point to other in a circular path. It is measured in radian.

Angular velocity

- The angular displacement in one second (rate of change of angular displacement) is called angular velocity.

$$\text{Angular velocity} = \frac{\text{Angular displacement}}{\text{Time taken}}$$

$\omega = \theta$

It is radian / second

Relation between linear velocity and angular velocity
$v = r\,\omega$

Newton's laws of motion

Newton's first law of motion

It states that everybody continues in its state of rest or of uniform motion along a straight line unless it is compelled by an external force to change that state.

Inertia

Inertia is that property of a body by virtue of which the body is unable to change its state by itself in the absence of external force.

Inertia depends upon its mass of the body.

The inertia is of three types

(i) Inertia of rest

Ex- A person standing in a bus falls backward when the bus suddenly starts moving.

(ii) Inertia of motion

Ex - When a passenger gets down from a moving bus, he falls down in the direction of the motion of the bus.

(iii) Inertia of direction.

Ex - When a bus moving along a straight line takes a turn to the right, the passengers are thrown towards left.

Momentum

- P = MV
- M = Mass
- V = Velocity
- It is Vector Unit
- Unit - kg m/s.

Newton's second law of motion

- ❖ The rate of change of momentum of a body is directly proportional to the external force applied on it and the change in momentum takes place in the direction of the force.
  F=ma
- ❖ The unit of force is kg m s^{-2} or Newton. Its dimensional formula is MLT^{-2}.

Example : 1

A constant force acts on an object of mass 10 kg for a duration of 4 s. It increases the objects velocity from 2 ms^{-1} to 8 m s^{-1} Find the magnitude of the applied force.

Solution:

Given, mass of the object m = 10 kg

Initial velocity u = 2 m s^{-1}

Final velocity v = 8 m s^{-1}

We know, force

$$F = \frac{m(v-u)}{t}$$

$$F = \frac{10(8-2)}{4} = 15\ N$$

Example : 2

Which would require a greater force for accelerating a 2 kg of mass at 4 m s^{-2} or a 3 kg mass at 2 m s^{-2}?

Solution

We know, force F = ma

Given m1 = 2kg a_1 = 4 ms^{-2}

m_2 = 3 kg a_2 = 2m s^{-2}

Thus, $F_1 = m_1 a_1$ = 2kg × 4m s^{-2} = **8 N**

and $F_2 = m_2 a_2$ = 3kg × 2m s^{-2} = **6 N**

⇒ F1 > F2

Impulsive force and Impulse of a force

(i) Impulsive Force

An impulsive force is a very great

A jet engine works under the principle of Law of conservation of Newton's third law linear momentum.

force acting for a very short time on a body, so that the change in the position of the body during the time the force acts on it may be neglected.

(e.g.) The blow of a hammer, the collision of two billiard balls etc.

(ii) Impulse of a force

The impulse J of a constant force F acting for a time t is defined as the product of the force and time.

(i.e) Impulse = Force × time

J = F × t

Impulse of a force is a vector quantity and its unit is Ns.

Newton's third Law of motion

For every action, there is an equal and opposite reaction.

Applications of Newton's third law of motion

(i) Apparent loss of weight in a lift

(ii) Working of a rocket and jet plane force

Centripetal Force

The constant force that acts on the body along the radius towards the centre and perpendicular to the velocity of the body is known as centripetal force

$F = \frac{mv^2}{r}$ ∴(since $v = r\omega$)

$F = mr\omega^2$

Examples

1. In the case of the stone tied to the end of a string and rotated in a circular path, the centripetal force is provided by the tension in the string.
2. When a car takes a turn on the road, the frictional force between the tyres and the road provides the centripetal force.
3. In the case of planets revolving round the sun or the moon revolving around the earth, the centripetal force is provided by the gravitational force of attraction between them
4. For an electron revolving around the nucleus in a circular path, the electro static force of attraction between the electron and the nucleus provides the necessary centripetal force.

When a body moves with uniform velocity its acceleration is zero

Centrifugal force

- The force which is equal in magnitude but opposite in direction to the centripetal force is known as centrifugal force.

Example : While churning curd, butter goes to the side due to centrifugal force.

Friction : Whenever a body slides over another body, a force comes into play between the two surfaces in contact and this force is known as frictional force. The frictional force always acts in the opposite direction to that of the motion of the body. The frictional force depends on the normal reaction. (Normal reaction is a perpendicular reactional force that acts on the body at the point of contact due to its own weight) (i.e) Frictional force α normal reaction $F \alpha R$ (or) $F = \mu R$ where μ is a proportionality constant and is known as the coefficient of friction. The coefficient of friction depends on the nature of the surface

Gravitation

- Newton concluded that all objects in the universe attract each other. This force of attraction between objects is called the gravitational force

Mass

- Mass is the amount of matter present in a body (or) is a measure of how much matter an object has.

Weight

Weight is the force which a given mass feels due to the gravity at its place (or) is a measure of how strongly gravity pulls on that matter.

	Mass	Weights
1.	Fundamental Quantity	Derived Quantity
2.	It is the amount of matter contained in a body	It is the gravitational pull acting on the body
3.	It's unit is kg	It is measured in newton
4.	Remains the same	Varies from place to place
5.	It is measured using physical balance	It is measured using spring balance

The energy gap of diamond is 7ev

Example : 1

Mass of an object is 5 kg. What is its weight on the earth?

Solution:

Mass, m = 5 kg Acceleration due to gravity, g = 9.8 m s^{-2}

Weight, w = m × g

w = 5 kg × 9.8 m s^{-2} = 49 N

Thus the weight of the object is, **49 N**

Example : 2

Calculate the energy produced when 1 kg of substance is fully converted into energy.

Solution: Energy produced, E = mc^2 Mass, m = 1 kg Velocity of light, c = 3×108 m s-1 E = 1 × (3 × 108)²

E = 9 × 10^{16} J

> **"In the absence of air, all bodies will fall at the same rate".**

Acceleration due to gravity

The gravitational force experienced by the body is $F = \frac{GMm}{R^2}$ where M is the R² mass of the earth. From Newton's second law of motion,

Force, F = mg

Equating the above two forces,

$$F = \frac{GMm}{R^2} \quad (\therefore\ F = mg)$$

$$mg = \frac{GM}{R^2}$$

Therefore,

$$g = \frac{GM}{R^2}$$

Mass of earth

From the expression $g = \frac{GM}{R^2}$, the mass of the Earth can be calculated as follows:

$$M = \frac{gR^2}{M}$$

$$M = \frac{9.8 \times (6.38 \times 10^6)^2}{6.67 \times 10^{-11}}$$

$$M = 5.98 \times 10^{24}\ \text{kg.}$$

Energy

- Energy can be defined as the capacity to do work. Energy can manifest itself in many forms like mechanical energy, thermal energy, electric energy, chemical energy, light energy, nuclear energy, etc. The energy possessed by a body due to its position or due to its motion is called mechanical energy. The mechanical energy of a body consists of potential energy and kinetic energy.

The path of a projective is parabola.

Potential energy

- The potential energy of a body is the energy stored in the body by virtue of its position or the state of strain. $E_P = mgh$

Example : Water stored in a reservoir, a wound spring, compressed air, stretched rubber chord, etc,

Kinetic energy

- The kinetic energy of a body is the energy possessed by the body by virtue of its motion.
  Kinetic energy $E_k = \frac{1}{2} Mv^2$
- A falling body, a bullet fired from a rifle, a swinging pendulum, etc.

Power

- It is defined as the rate at which work is done.

$$\text{Power} = \frac{\text{Work Done}}{\text{Time}}$$

- Its unit is watt and dimensional formula is $ML^2 T^{-3}$.

ELECTRICITY

Electricity

- A continuous and closed path of an electric current is called an electric circuit.
- Electric current is expressed by the amount of charge flowing through a particular area of cross section of a conductor in unit time.
- The direction of electric current is taken as opposite to the direction of the flow of electrons.

$$I = Q/t$$

- The S.I unit of electric charge is **coulomb.**
- This is equivalent to the charge contained in nearly 6×10^{18} electrons.

Example – 1:

A current of 0.75 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.

Solution:

Given, I = 0.75 A,

t = 10 minutes = 600 s

We know, $Q = I \times t$

$= 0.75\ A \times 600\ s$

$\mathbf{Q = 450\ C}$

ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE:

- We define the electric potential difference between two points in an electric circuit carrying current as the work done to move a unit charge from one point to the other.

$$V = W/Q$$

- The S.I Unit of potential difference is volt (V)
- 1 volt = 1joule/1coulomb
- One volt is the potential difference between two points in a cur- rent carrying conductor when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

Example – 2:

How much work is done in moving a charge of 5 C across two points having a potential difference 10 V?

Solution:

Given charge, Q = 5 C

Potential difference, V = 10 V

The amount of work done in moving the charge, W = V × Q

$$W = 10\ V \times 5C$$
$$W = \mathbf{50\ J}$$

- Nichrome is an alloy of Nickel, Chromium, Manganese and Iron metals
- Ohm's law states that at constant temperature the steady current (I) flowing through a conductor is directly proportional to the potential difference (V) between its ends.

$$\mathbf{V \propto I \text{ (or) } V/I = constant}$$

- Resistor S.I unit is ohm, represented by the Greek letter Ω.
- If the potential difference across the two ends of a conductor is 1 volt and the current through it is 1 ampere, then the resistance of the conductor is 1 ohm.

Example – 3:

The potential difference between the terminals of an electric heater is 60 V when it draws a current of 5 A from the source. What current will the heater draw if the potential difference is increased to 120 V?

Solution:

Given the potential difference,

V = 60 V

Current, I = 5 A

According to ohm's law,

R = V/I = 60 V / 5 A = 12 Ω

When the potential difference is increased to 120 V,

the current is given by

I = V/R = 120 V / 12 Ω = 10 A

SYSTEM OF RESISTORS:

Resistors in series:

- The total potential difference across the combination of resistors in series is equal to the sum of potential difference across individual resistors. That is,

$$\mathbf{V = V_1+V_2+V_3}$$
$$\mathbf{R_s = R_1+R_2+R_3}$$

- The resistance of the combination Rs is equal to the sum of their individual resistances R1, R2, R3 and is thus greater than any individual resistance.

Example – 4:

Two resistances 18 Ω and 6 Ω are connected to a 6 V battery in series. Calculate (a) the total resistance of the circuit, (b) the current through the circuit.

Solution:

(a) Given the resistance,

R1 = 18 Ω R2 = 6 Ω

The total resistance of the circuit

RS = R1 + R2 RS = 18 Ω + 6 Ω **= 24** Ω

(b) The potential difference across the two terminals of the battery

V = 6 V

Now the current through the circuit,

I = V/ RS = 6 V / 24 Ω = **0.25 A**

Resistors in parallel:

- In parallel combination the potential difference across each resistor is the same having a value V. The total current I is equal to the sum of the separate currents through each branch of the combination.

$$I = I_1 + I_2 + I_3$$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

- Thus the reciprocal of the equivalent resistance of a group of resistance joined in parallel is equal to the sum of the reciprocals of the individual resistance.

Example – 5:

Three resistances having the values 5 Ω, 10 Ω, 30 Ω are connected parallel with each other. Calculate the total circuit resistance.

Solution: Given, R1 = 5 Ω

R2 = 10 Ω

R3 = 30 Ω

These resistances are connected parallel therefore,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_P} = \frac{1}{5} + \frac{1}{10} + \frac{1}{30} = \frac{10}{30}$$

$$R_P = \frac{30}{10} = 3\Omega$$

JOULES LAW OF HEATING:

- Consider a current I flowing through a resistor of resistance R. Let the potential difference across it be V.

$P = V(Q/t) = VI$

$\mathbf{H = V\,It}$

- Applying Ohm's law we get $\mathbf{H = I^2 Rt}$. This is known as Joule's law of heating.
- The law implies that heat produced in a resistor is (1) directly proportional to the square of current for a given resistance, (2) directly proportional to the resistance for a given current, and (3) directly proportional to the time for which the current flows through the resistor.

Some applications of Joule heating:

(i) Electric heating device:

Electric iron, electric heater, electric toaster are some of the appliances that work on the principle of heating effect of current. In these appliances, Nichrome which is an alloy of nickel and chromium is used as the heating element for the following reasons.

(1) It has high specific resistance

(2) It has high melting point

(3) It is not easily oxidized

(ii) Fuse wire:

Fuse wire is an alloy of lead 37% and tin 63%. It is connected in series in an electric circuit. It has high resistance and low melting point.

(iii) Electric bulb:

Electric arc and electric welding also work on the principle of heating effect of current.

Example – 6: A potential difference 20 V is applied across a 4 Ω resistor. Find the rate of production of heat.

Solution:

Given potential difference,

$V = 20\ V$

The resistance,

$R = 4\ \Omega$

The time,

$t = 1\ s$

According to ohm's law,

$I = V / R \qquad I = 20\ V / 4\ \Omega = 5\ A$

The rate of production of heat,

$H = I^2 Rt \qquad H = 5^2 \times 4 \times 1$

$H = 100J$

Transformers are used to step up or step down AC voltage

ROLE OF FUSE:

A common application of Joule's heating is the fuse used in electric circuits.

DOMESTIC ELECTRIC CIRCUITS:

- One of the wires in the supply, usually with red insulation cover, is called live wire (or positive). Another wire, with black insulation, is called neutral wire (or negative). In our country, the potential differences between the two are 220 V.

- The earth wire which has insulation of green colour is usually connected to a metal plate deep in the earth near the house.

ELECTRIC POWER:

We know already that the rate of doing work is power. This is also the rate of consumption of energy. This is also termed as electric power.

The power P is given by

$\boxed{P = VI} = PI^2 \quad R = V^2/R$

- The SI unit of electric power is watt (W). It is the power consumed by a device that carries 1 A of current when operated at a potential difference of 1V.
- Thus, 1 W = 1 volt × 1 ampere = 1 VA
- The unit of electric energy is, therefore, watt hour (Wh). One watt hour is the energy consumed when one watt of power is used for one hour. The commercial unit of electric energy is kilowatt hour (KWh), commonly known as unit.
- 1 kWh = 1000watt × 3600second

  $= 3.6\times 10^6$ watt second

  $= 3.6 \times 10^6$ joule (J)

Drift velocity and mobility:

- Drift velocity is defined as the velocity with which free electrons get drifted towards the positive terminal, when an electric field is applied. If τ is the average time between two successive collisions and the acceleration experienced by the electron be a, then the drift velocity is given by,

$$\mathbf{v_d = a\tau}$$

$\boldsymbol{\mu = \frac{e\tau}{m}}$ is the mobility and is defined as the drift velocity acquired per unit electric field.

- Its unit is $m^2V^{-1}s^{-1}$

- The drift velocity of electrons is proportional to the electric field intensity.
- It is very small and is of the order of 0.1 cm s^{-1}

Current density:

- Current density at a point is defined as the quantity of charge passing per unit time through unit area, taken perpendicular to the direction of flow of charge at that point.
- The current density **J** for a current I flowing across a conductor having an area of cross section A is

$$\mathbf{J = \frac{(q/t)}{A} = \frac{I}{A}}$$

- Current density is a vector quantity. It is expressed in A m^{-2}

Classification of materials in terms of resistivity:

- The resistivity of a material is the characteristic of that particular material. The materials can be broadly classified into conductors and insulators.
- The metals and alloys which have low resistivity of the order of $10^{-6} - 10^{-8} \Omega$ m are good conductors of electricity.
- They carry current without appreciable loss of energy.
- Example: silver, aluminium, copper, iron, tungsten, nichrome, manganin, constantan.
- The resistivity of metals increase with increase in temperature.
- Insulators are substances which have very high resistivity of the order of $10^{8} - 10^{14} \Omega$ m.
- They offer very high resistance to the flow of current and are termed non–conductors.
- Example: glass, mica, amber, quartz, wood, teflon, bakelite.
- In between these two classes of materials lie the semiconductors. They are partially conducting. The resistivity of semiconductor is $10^{-2} - 10^{4} \Omega$ m.
- Example: germanium, silicon.

Superconductivity:

- The ability of certain metals, their compounds and alloys to conduct electricity with zero resistance at very low temperatures is called superconductivity. The materials which exhibit this property are called superconductors.

- The materials which exhibit this property are called superconductors.
- The phenomenon of superconductivity was first observed by Kammerlingh Onnes in 1911. He found that mercury suddenly showed zero resistance at 4.2 K.
- The first theoretical explanation of superconductivity was given by Bardeen, Cooper and Schrieffer in 1957 and it is called the BCS theory.
- The temperature at which electrical resistivity of the material suddenly drops to zero and the material changes from normal conductor to a superconductor is called the transition temperature or critical temperature TC.

At the transition temperature the following changes are observed :

(i) The electrical resistivity drops to zero.

(ii) The conductivity becomes infinity

(iii) The magnetic flux lines are excluded from the material.

Applications of superconductors:

- Superconductors form the basis of energy saving power systems, namely the superconducting generators, which are smaller in size and weight, in comparison with conventional generators.
- Superconducting magnets have been used to levitate trains above its rails. They can be driven at high speed with minimal expenditure of energy.
- Superconducting magnetic propulsion systems may be used to launch satellites into orbits directly from the earth without the use of rockets.
- High efficiency ore–separating machines may be built using superconducting magnets which can be used to separate tumor cells from healthy cells by high gradient magnetic separation method.
- Since the current in a superconducting wire can flow without any change in magnitude, it can be used for transmission lines.
- Superconductors can be used as memory or storage elements in computers.

The heating element in an electric stove is made of Nichrome.

Carbon resistors:

- Carbon resistor consists of a ceramic core, on which a thin layer of crystalline carbon is deposited.
- These resistors are cheaper, stable and small in size.

Kirchoff's law:

1. Kirchoff's first law (current law)
2. Kirchoff's second law (voltage law)

Kirchoff's first law (current law):

- Kirchoff's current law states that the algebraic sum of the currents meeting at any junction in a circuit is zero.
- The sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

Kirchoff's second law (voltage law):

- Kirchoff's voltage law states that the algebraic sum of the products of resistance and current in each part of any closed circuit is equal to the algebraic sum of the emf's in that closed circuit. This law is a consequence of conservation of energy.

Wheatstone's bridge:

- An important application of Kirchoff's law is the Wheatstone's bridge.

$$\frac{P}{Q} = \frac{R}{S}$$

Metre bridge:

- Metre bridge is one form of W h e a t s t o n e's bridge.

Determination of specific resistance:

- The specific resistance of the material of a wire is determined by knowing the resistance (P), radius (r) and length (L) of the wire using the expression $\rho = \frac{P\pi r^2}{L}$

Potentiometer:

- The Potentiometer is an instrument used for the measurement of potential difference.

Chemical effect of current:

- The passage of an electric current through a liquid causes chemical changes and this process is called electrolysis.
- The conduction is possible, only in liquids wherein charged ions can

be dissociated in opposite directions. Such liquids are called electrolytes.

- The plates through which current enters and leaves an electrolyte are known as electrodes.
- The electrode towards which positive ions travel is called the cathode and the other, towards which negative ions travel is called anode.

Faraday's laws of electrolysis:

- The factors affecting the quantities of matter liberated during the process of electrolysis were investigated by Faraday.

Electric cells:

- The starting point to the development of electric cells is the classic experiment by Luige Galvani and his wife Lucia on a dissected frog hung from iron railings with brass hooks.

Voltaic cell:

- The simple cell or voltaic cell consists of two electrodes, one of copper and the other of zinc dipped in a solution of dilute sulphuric acid in a glass vessel.
- Anode : Copper (Cu)
- Cathode : Zinc (Zn)
- Potential Difference : 1.08V
- Electrolyte : H_2SO_4

Primary Cell:

- The cells from which the electric energy is derived by irreversible chemical actions are called primary cells.

Daniel cell:

- Daniel cell is a primary cell which cannot supply steady current for a long time.

Leclanche cell:

- The emf of the cell is about 1.5 V, and it can supply a current of 0.25 A.
- Anode: Carbon rod
- Cathode: Zinc rod
- Electrolyte: Ammonium chloride

Secondary Cells:

- Anode : Lead
- Cathode : Lead Oxide
- Electrolyte : H_2SO_4
- The advantage of secondary cells is that they are rechargeable.

- The chemical process of obtaining current from a secondary cell is called discharge.

Seebeck effect:

- In 1821, German Physicist Thomas Johann See beck discovered that in a circuit consisting of two dissimilar metals like iron and copper, an emf is developed when the junctions are maintained at different temperatures.
- Two dissimilar metals connected to form two junctions is called thermocouple.
- The emf developed in the circuit is thermo electric emf.
- The current through the circuit is called thermoelectric current. This effect is called thermoelectric effect or Seebeck effect.

Peltier effect:

- In 1834, a French scientist Peltier discovered that when electric current is passed through a circuit consisting of two dissimilar metals, heat is evolved at one junction and absorbed at the other junction. This is called Peltier effect. Peltier effect is the converse of Seebeck effect.

Peltier Co-efficient(π):

- The amount of heat energy absorbed or evolved at one of the junctions of a thermocouple when one ampere current flows for one second (one coulomb) is called Peltier coefficient.
- It is denoted by π. Its unit is volt.

Thomson effect:

- Thomson suggested that when a current flows through unequally heated conductors, heat energy is absorbed or evolved throughout the body of the metal.
- Positive Thomson effect is observed in the case of Sb, Ag, Zn, Cd, etc.
- Negative Thomson effect is observed in the case of Pt, Bi, Co, Ni, Hg, etc.
- In the case of lead, Thomson effect is nil.

Thomson coefficient(σ):

- The amount of heat energy absorbed or evolved when one ampere current flows for one second (one coulomb) in a metal between two points which differ in temperature by 1°C is called

Thomson coefficient. It is denoted by σ.Its unit is volt per ° C

Magnetic effect of current:

- In 1820, Danish Physicist, Hans Christian Oersted observed that current through a wire caused a deflection in a nearby magnetic needle. This indicates that magnetic field is associated with a current carrying conductor.

Magnetic induction due to infinitely long straight conductor carrying current:

$$B = \frac{\mu_0 I}{2\pi a}$$

If the conductor is placed in a medium of permeability, μ

$$B = \frac{\mu I}{2\pi a}$$

Tangent galvanometer:

- Tangent galvanometer is a device used for measuring current.
- Since the tangent galvanometer is most sensitive at a deflection of 45°, the deflection has to be adjusted to be between 30° and 60°.

Cyclotron:

- Cyclotron is a device used to accelerate charged particles to high energies. It was devised by Lawrence.

Force on a current carrying conductor placed in a magnetic field:

$$\vec{F} = \vec{Il} \times \vec{B}$$

Pointer type moving coil galvanometer:

- The suspended coil galvanometers are very sensitive. They can measure current of the order of 10^{-8} ampere.

Conversion of galvanometer into an ammeter:

- A galvanometer is a device used to detect the flow of current in an electrical circuit.
- However, a galvanometer is converted into an ammeter by connecting a low resistance in parallel with it.
- As a result, when large current flows in a circuit, only a small fraction of the current passes

Gas lighters work on the basic principle of Piezo – electric effect through the galvanometer and the remaining larger portion of the current passes through the low resistance.

- The low resistance connected in parallel with the galvanometer is called shunt resistance. The scale is marked in ampere.
- R_a is very low and this explains why an ammeter should be connected in series. When connected in series, the ammeter does not appreciably change the resistance and current in the circuit. Hence an ideal ammeter is one which has zero resistance.

Conversion of galvanometer into a voltmeter:

- A galvanometer can be converted into a voltmeter by connecting a high resistance in series with it. The scale is calibrated in volt.
- R_v is very large, and hence a voltmeter is connected in parallel in a circuit as it draws the least current from the circuit.

Bohr magneton:

- The value of $\frac{eh}{4\pi m}$ is called Bohr magneton.
- By substituting the values of e, h and m, the value of Bohr magneton is found to be $9.27\times10^{-24} Am^2$

Electricity:

- AC to DC – Rectifier
- DC to AC – Inverter
- Transformer – Changes from one voltage to another

MAGNETISM

Magnetism

- The word magnetism is derived from iron ore magnetite (Fe_3O_4), which was found in the island of magnesia in Greece. Gilbert who laid the foundation for magnetism and had suggested that Earth itself behaves as a giant bar magnet. The field at the surface of the Earth is approximately 10^{-4} T and the field extends upto a height of nearly five times the radius of the Earth.

Causes of the Earth's magnetism

- The exact cause of the Earth's magnetism is not known even today. However, some important factors which may be the cause of Earth's magnetism are:
  1. Magnetic masses in the Earth.
  2. Electric currents in the Earth.
  3. Electric currents in the upper regions of the atmosphere.
  4. Radiations from the Sun.
  5. Action of moon etc.
- However, it is believed that the Earth's magnetic field is due to the molten charged metallic fluid inside the Earth's surface with a core of radius about 3500 km compared to the Earth's radius of 6400 km.

Basic properties of magnets

(i) When the magnet is dipped in iron filings, they cling to the ends of the magnet. The attraction is maximum at the two ends of the magnet. These ends are called poles of the magnet.

(ii) When a magnet is freely suspended, it always points along north-south direction. The pole pointing towards geographic north is called north pole N and the pole which points towards geographic south is called south pole S.

(iii) Magnetic poles always exist in pairs. (i.e) isolated magnetic pole does not exist.

(iv) The magnetic length of a magnet is always less than its geometric length, because the poles are situated a little inwards from the free ends of the magnet. (But for the purpose of calculation the geometric length is always taken as magnetic length.)

(v) Like poles repel each other and unlike poles attract each other. North pole of a magnet when brought near north pole of another magnet, we can observe repulsion, but when the north pole of one magnet is brought near south pole of another magnet, we observe attraction.

(vi) The force of attraction or repulsion between two magnetic poles is given by Coulomb's inverse square law.

Note : In recent days, the concept of magnetic poles has been completely changed. The origin of magnetism is traced only due to the flow of current. But anyhow, we have retained the conventional idea of magnetic poles in this chapter. Pole strength is denoted by m and its unit is ampere metre.

Magnetic moment

- The magnetic moment of a magnet is defined as the product of the pole strength and the distance between the two poles. Magnetic moment is a vector quantity. It is denoted by M. Its unit is A m^2. Its direction is from south pole to north pole.

Magnetic field

- Magnetic field is the space in which a magnetic pole experiences a force or it is the space around a magnet in which the influence of the magnet is felt.

Magnetic induction

- Magnetic induction is the fundamental character of a magnetic field at a point. It is a vector quantity. It is also called as magnetic flux density.

Properties of magnetic lines of force

1. Magnetic lines of forces are closed continuous curves, extending through the body of the magnet.

2. The direction of line of force is from north pole to south pole outside the magnet while it is from south pole to north pole inside the magnet.
3. The tangent to the magnetic line of force at any point gives the direction of magnetic field at that point. (i.e) it gives the direction of magnetic induction ($\rightarrow$ B) at that point.
4. They never intersect each other.
5. They crowd where the magnetic field is strong and thin out where the field is weak.

Magnetic flux and magnetic flux density

❖ The number of magnetic lines of force passing through an area A is called magnetic flux. It is denoted by φ. Its unit is weber. It is a scalar quantity.

Tangent law

❖ A magnetic needle suspended, at a point where there are two crossed magnetic fields acting at right angles to each other, will come to rest in the direction of the resultant of the two fields

$$B_1 = B_2 \tan \theta$$

Magnetic properties of materials

❖ Classifying the materials depending on their magnetic behavior **Magnetising field or magnetic intensity** The magnetic field used to magnetise a material is called the Magnetising field. It is denoted by H and its unit is A m^{-1}.

Magnetic permeability

❖ Magnetic permeability is the ability of the material to allow the passage of magnetic lines of force through it.

Intensity of magnetization

❖ Intensity of magnetisation of a magnetic material is defined as the magnetic moment per unit volume of the material.

$$I = M/V$$

Its unit is A m^{-1}.

Magnetic induction

❖ When a soft iron bar is placed in a uniform magnetising field H, the magnetic induction inside the specimen B is equal to the sum of the magnetic induction Bo produced in vacuum due to the magnetising field and the magnetic induction Bm due to the induced magnetisation of the specimen.

$$B = \mu_o (H + I)$$

Magnetic susceptibility

- Susceptibility of a magnetic material is defined as the ratio of intensity of magnetisation I induced in the material to the magnetising field H in which the material is placed

Classification of magnetic materials

- On the basis of the behaviour of materials in a magnetising field, the materials are generally classified into three categories namely,
  (i) Diamagnetic,
  (ii) Paramagnetic
  and (iii) Ferromagnetic

Properties of diamagnetic substances

- Diamagnetic substances are those in which the net magnetic moment of atoms is zero.

1. The susceptibility has a low negative value. (For example, for bismuth $\chi m = -$ 0.00017).
2. Susceptibility is independent of temperature.
3. The relative permeability is slightly less than one.
4. When placed in a non uniform magnetic field they have a tendency to move away from the field. (i.e) from the stronger part to the weaker part of the field. They get magnetized in a direction opposite to the field as shown.
5. When suspended freely in a uniform magnetic field, they set themselves perpendicular to the direction of the magnetic field

Ex: Bi, Sb, Cu, Au, Hg, H_2O, H_2 etc.

Properties of paramagnetic substances

Paramagnetic substances are those in which each atom or molecule has a net non-zero magnetic moment of its own.

1. Susceptibility has a low positive value.
2. Susceptibility is inversely proportional to absolute temperature (i.e) X_m x $\frac{1}{T}$. As the temperature increases susceptibility decreases.

3. The relative permeability is greater than one.
4. When placed in a non uniform magnetic field, they have a tendency to move from weaker part to the stronger part of the field. They get magnetised in the direction of the field When suspended freely in a uniform magnetic field, they set themselves parallel to the direction of magnetic field

Ex: Al, Pt, Cr, O2, Mn, CuSO4 etc.

Properties of ferromagnetic substances

- Ferromagnetic substances are those in which each atom or molecule has a strong spontaneous net magnetic moment. These substances exhibit strong paramagnetic properties.

1. The susceptibility and relative permeability are very large.
   (For example : μr for iron = 200,000)
2. Susceptibility is inversely proportional to the absolute temperature X_m x $\frac{1}{T}$. As the temperature increases the value of susceptibility decreases. At a particular temperature, ferromagnetics become paramagnetics. This transition temperature is called curie temperature. For example curie temperature of iron is about 1000 K.
3. When suspended freely in uniform magnetic field, they set themselves parallel to the direction of magnetic field.
4. When placed in a non uniform magnetic field, they have a tendency to move from the weaker part to the stronger part of the field. They get strongly magnetised in the direction of the field.

Ex : Fe, Ni, Co and a number of their alloys

Uses of ferromagnetic materials

(i) Permanent magnets

- The ideal material for making permanent magnets should possess high retentivity (residual magnetism) and high coercivity so that the magnetisation lasts for a longer time. Examples of such substances are steel and alnico (an alloy of Al, Ni and Co).

Electromagnets

- Material used for making an electromagnet has to undergo cyclic changes least hysteresis loss high values of magnetic induction B at low values of magnetising field H. Soft iron is preferred for making electromagnets as it has a thin hysteresis loop and low retentively.

Core of the transformer

- A material used for making transformer core and choke is subjected to cyclic changes very rapidly.

Magnetic tapes and memory store

- Magnetisation of a magnet depends not only on the magnetizing field but also on the cycle of magnetisation it has undergone. Thus, the value of magnetisation of the specimen is a record of the cycles of magnetisation it has undergone. Therefore, such a system can act as a device for storing memory. Ferro magnetic materials are used for coating magnetic tapes in a cassette player and for building a memory store in a modern computer.

Ex: Ferrites (Fe, Fe_2O, $MnFe_2O_4$ etc.).

Fleming left hand rule

- Stretch the thumb, fore finger and middle finger of your left hand such that they are mutually perpendicular. If the forefinger points in the direction of magnetic field and the middle finger points in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor.

Fleming's right hand rule.

- Stretch the thumb, forefinger and middle finger of right hand so that they are perpendicular to each other. If the forefinger indicates the direction of the magnetic field and the thumb shows the direction of motion of conductor, then the middle finger will show the direction of induced current.

HEAT AND THERMODYNAMICS

Heat

- Temperature is the thermal state of the body, that decides the direction of flow of heat.
- "Heat is a form of energy transfer between two systems or between a system and its surroundings due to temperature difference between them.

Specific heat capacity

Specific heat capacity of a substance is defined as the quantity of heat required to raise the temperature of 1 kg of the substance through 1K. Its unit is J $kg^{-1}K^{-1}$.

- The specific heat capacity of water is the highest for any substance, 4180 J/kg K. It is 30 times the specific heat capacity of mercury which is about 140J/kg K.

Specific Latent Heat

Specific Latent Heat of fusion of any substance is the quantity of heat energy required to melt one kilogram of a substance without change in temperature. The symbol used is L. The unit for specific latent heat is Joule/kilogram or J/kg

The Gas Laws

- **Boyle's Law**
  "Temperature remaining constant, the pressure of a given mass of gas is inversely proportional to its volume". [Temp remaining constant] It can also be stated as PV = a constant

Charles' law

- **Charles' Law**
  States that "Pressure remaining constant, the volume of a given mass of gas is directly

Mercury boils at 357 °C

proportional to the absolute temperature". This is referred to as the law of volumes. A constant [Pressure remaining constant]

It can also be stated as V α T

V/T = a constant

Kelvin Scale or Absolute Temperature

- The zero of the Kelvin scale corresponds to -273°C and is written as 0K (without the degree symbol). One division on the Kelvin scale has the same magnitude of temperature as one division of the Celsius or Centigrade scale. Thus 0°C corresponds to +273K.

Kelvin scale(K) = Celsius scale (0°C) + 273

Celsius scale (0°C) = Kelvin scale (K) – 273

Adiabatic process

In Greek, adiabatic means "nothing passes through". The process in which pressure, volume and temperature of a system change in such a manner that during the change no heat enters or leaves the system is called adiabatic process. Thus in adiabatic process, the total heat of the system remains constant

Carnot engine

- Heat engine is a device which converts heat energy into mechanical energy.

Refrigerator

- A refrigerator is a cooling device. An ideal refrigerator can be regarded as Carnot's heat engine working in the reverse direction. Therefore, it is also called a heat pump

Transfer of heat

- There are three ways in which heat energy may get transferred from one place to another. These are conduction, convection and radiation

Conduction

- Heat is transmitted through the solids by the process of conduction

Applications

i. The houses of Eskimos are made up of double walled blocks of ice. Air enclosed in between the double walls prevents

Land and sea breeze are due to convection of heat transmission of heat from the house to the coldest surroundings.

ii. Birds often swell their feathers in winter to enclose air between their body and the feathers. Air prevents the loss of heat from the body of the bird to the cold surroundings.

iii. Ice is packed in gunny bags or sawdust because, air trapped in the saw dust prevents the transfer of heat from the surroundings to the ice. Hence ice does not melt

Convection

❖ It is a phenomenon of transfer of heat in a fluid with the actual movement of the particles of the fluid

Application

❖ It plays an important role in ventilation and in heating and cooling system of the houses.

Radiation

❖ It is the phenomenon of transfer of heat without any material medium. Such a process of heat transfer in which no material medium takes part is known as radiation.

Thermal radiation

❖ The energy emitted by a body in the form of radiation on account of its temperature is called thermal radiation.

It depends on,

(i) Temperature of the body,

(ii) Nature of the radiating body

❖ The wavelength of thermal radiation ranges from 8×10^{-7}m to 4×10^{-4}m. They belong to infra-red region of the electromagnetic spectrum.

Properties of thermal radiations

1. Thermal radiations can travel through vacuum.
2. They travel along straight lines with the speed of light.
3. They can be reflected and refracted. They exhibit the phenomenon of interference and diffraction.
4. They do not heat the intervening medium through which they pass.
5. They obey inverse square law.

Emissive power

❖ Emissive power of a body at a given temperature is the amount of energy emitted per unit time per unit area of the surface for a given

The colour of a star is an indication of its temperature wavelength. It is denoted by e_λ. Its unit is W m^{-2}.

Perfect black body

- A perfect black body is the one which absorbs completely heat radiations of all wavelengths which fall on it and emits heat radiations of all wavelengths when heated. Since a perfect black body neither reflects nor transmits any radiation, the absorptive power of a perfectly black body is unity.

Kirchoff's Law

- According to this law, the ratio of emissive power to the absorptive power corresponding to a particular wavelength and at a given temperature is always a constant for all bodies.

$$\frac{e_\lambda}{a_\lambda} = \text{constant} = E_\lambda$$

Stefan's law

- Stefan's law states that the total amount of heat energy radiated per second per unit area of a perfect black body is directly proportional to the fourth power of its absolute temperature.

(i.e) $E \alpha T^4$ or $E = \sigma T^4$

- Where σ is called the Stefan's constant. Its value is 5.67×10^{-8} W m^{-2} K^{-4}.

NEWTON'S LAW OF COOLING

Newton's law of cooling states that the rate of cooling of a body is directly proportional to the temperature difference between the body and the surroundings

Solar constant

- The solar constant is the amount of radiant energy received per second per unit area by a perfect black body on the Earth with its surface perpendicular to the direction of radiation from the sun in the absence of atmosphere. It is denoted by S and its value is 1.388×10^3 W m^{-2}. Surface temperature of the Sun can be calculated from solar constant.

Angstrom Pyrheliometer

- Pyrheliometer is an instrument used to measure the quantity of heat radiation and solar constant.

Sea water turns into ice at 4 ℃

LIGHT

LIGHT

Rectilinear Propagation, Shadows and Eclipse :

- Light travels in straight line.
- The kind of shadow depends on the size of the source of light
- Shadow obtained is a region of total darkness called umbra
- Shadow obtained partial darkness called penumbra.
- Lunar eclipse - earth comes between the sun and the moon.
- Solar eclipse - moon comes between the sun and the earth.

Reflection of light

❖ A highly polished surface, such as a mirror, reflects most of the light falling on it.

(i) The angle of incidence is equal to the angle of reflection, and

$$\angle i = \angle r$$

(ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

An image formed in a plane mirror has the following Characteristics.

- The image is of the same size as the object.
- It is as behind the mirror as the object is in front of it.
- It is virtual
- It is laterally inverted.

❖ Light is incident on a rough surface, the reflected rays are scattered in all direction the many surface irregularities. This is called diffuse reflection.

Inclined mirror :

❖ When an object is placed between two inclined mirrors several images of the object one formed

❖ Number of images depends on the angle between the mirror.

$$\textbf{No. of image} = \frac{360^0}{\text{angle between mirrors}}$$

Kaleidoscope :

- It is toy image are formed by two strips of plane mirrors placed at an angle of 60^o inside the tube five images are seen.

Refraction :

- Light bends when its travel from one medium to another this called refraction of the lights.
- Different speeds of light in medium different densities.
- Speed of light in vaccum - 3×10^8 m/s.
- When light travels from a rarer medium and enters a denser medium it will be deviated towards to the normal line

  Ex : From air to glass.

- The light will be deviated away from the normal when it passes from a denser into a rare medium

  Ex : Glass to Air.

Atmosphere Refraction

- The density of the atmosphere surrounding the earth decreases with increasing altitude. Thus if light enters the atmosphere from outside it encounters layers of air increasing density and, therefore, bends gradually producing a curved path.

  Ex - Star twinkling, Mirage

Refractive Index

$$\mu = \frac{Sin\ i}{Sin\ r} = \frac{\text{Velocity of light in air}}{\text{Velocity of light in medium}}$$

It has no unit & no dimension

- Water - 1.33
- Crown glass - 1.52
- Dense Flint glass - 1.62
- Diamond - 2.42

Total Internal Reflection :

- Ray or light passes through the denser medium to the rare medium the refracted Ray is bent away from the normal line.
- Angle of incidence increase the angle of refraction also increase.
- At a certain angle of incidence the angle of reflection becomes

The colour of outer edge of rainbow will be red.

90^{o}. This angle is called critical angle (c).

- ❖ If the angle of incidence is more than the critical angle the rays bends inside the denser medium itself. This phenomenon is called **total internal reflection.**

Optical Fibre

- ❖ An optical fibre is a device based on the principle of total internal reflection.
- ❖ Optical fibres are thin, flexible and transparent strands of glass which can carry light along them very easily. A boundle of such thin fibres from a light pipe.

Uses of Optical Fibre

- ❖ Optical fibres are used to transmit communication signals.
- ❖ In medicine, optical fibres are used endoscope and laparoscopes.

Dispersion

- ❖ Separation of light into colours is called dispersion.
- ❖ Seven colours - Violet, Indigo, Blue, Green, Yellow, Orange and Red.
- ❖ Violet Colour Minimium Wave Length and Maximum Frequency.
- ❖ Red Colour - Maximum Wave Length and Minimum Frequency.
- ❖ Vaccum all colours are same speed but different medium and different speed.

The Rainbow

- ❖ The most spectacular illustration of dispersion.
- ❖ Droplets acts as a prism.
- ❖ Rainbow is seen in the sky opposite the sun.
- ❖ Each droplets there is dispersion as well as total internal reflection.

Colour of objects

- ❖ Leaves reflect the green colour the remaining colour are observed.

Mixing Coloured Light

- ❖ All colours can be suitable mixture of these three colour. (Red, Blue, Green) Therefore called primary colour, others secondary colour.
- ❖ The colours which give white light when put together, are called complementary colour blue + yellow - complementary colours.

Scattering of light

- Lord Rayleigh was the first to deal with scattering of light by air molecules. The scattering of sunlight by the molecules of the gases in Earth's atmosphere is called Rayleigh scattering. The basic process in scattering is absorption of light by the molecules followed by its re-radiation in different directions. The strength of scattering depends on the wavelength of the light and also the size of the particle which cause scattering. The amount of scattering is inversely proportional to the fourth power of the wavelength. This is known as Rayleigh scattering law.
- Hence, the shorter wavelengths are scattered much more than the longer wavelengths. The blue appearance of sky is due to scattering of sunlight by the atmosphere. According to Rayleigh's scattering law, blue light is scattered to a greater extent than red light. This scattered radiation causes the sky to appear blue.
- At sunrise and sunset the rays from the sun have to travel a larger part of the atmosphere than at noon. Therefore most of the blue light is scattered away and only the red light which is least scattered reaches the observer. Hence, sun appears reddish at sunrise and sunset

Tyndal scattering

- The scattering of light by the colloidal particles is called Tyndal scattering.

Diffraction

- Sound is propagated in the form of waves. Sound produced in an adjoining room reaches us after bending round the edges of the walls. Similarly, waves on the surface of water also bend round the edges of an obstacle and spread into the region behind it. This bending of waves around the edges of an obstacle is called diffraction. Diffraction is a characteristic property of waves. The waves are diffracted, only when the size of the obstacle is comparable to the wavelength of the wave.

The sky appears to be blue because of scattering of light.

❖ Fresnel showed that the amount of bending produced at an obstacle depends upon the wavelength of the incident wave. Since **the sound waves have a greater wavelength, the diffraction effects are pronounced. As the wavelength of light is very small, compared to that of sound wave and even tiny obstacles have large size, compared to the wavelength of light waves, diffraction effects of light are very small.**

Fresnel and Fraunhofer diffraction

Diffraction phenomenon can be classified under two groups (i) Fresnel diffraction and (ii) Fraunhofer diffraction

Polarisation

The phenomena of reflection, refraction, interference, diffraction are common to both transverse waves and longitudinal waves. But the transverse nature of light waves is demonstrated only by the phenomenon of polarization

The phenomenon of restricting the vibrations into a particular plane is known as polarization (for glass it is 57.5o)

Types of crystals

Crystals like calcite, quartz, ice and tourmaline having only one optic axis are called uniaxial crystals. Crystals like mica, topaz, selenite and aragonite having two optic axes are called biaxial crystals

Polaroids

A Polaroid is a material which polarises light. The phenomenon of selective absorption is made use of in the construction of polariods

Uses of Polaroid

1. Polaroids are used in the laboratory to produce and analyse plane polarised light.
2. Polaroids are widely used as polarising sun glasses.
3. They are used to eliminate the head light glare in motor cars.
4. They are used to improve colour contrasts in old oil paintings.
5. Polaroid films are used to produce

We cannot see during a fog because scattering of light three – dimensional moving pictures.

6. They are used as glass windows in trains and aeroplanes to control the intensity of light. In aeroplane one polaroid is fixed outside the window while the other is fitted inside which can be rotated. The intensity of light can be adjusted by rotating the inner polaroid.
7. Aerial pictures may be taken from slightly different angles and when viewed through polaroids give a better perception of depth.
8. In calculators and watches, letters and numbers are formed by liquid crystal display (LCD) through polarisation of light.
9. Polarisation is also used to study size and shape of molecules

Theories of light

Corpuscular theory

❖ According to Newton, a source of light or a luminous body continuously emits tiny, massless (negligibly small mass) and perfectly elastic particles called corpuscles. They travel in straight lines in a homogeneous medium in all directions with the speed of light

❖ **Wave theory**

According to Huygens, light is propagated in the form of waves, through a continuous medium. Huygens assumed the existence of an invisible, elastic medium called ether, which pervades all space

❖ **Electromagnetic theory**

Maxwell showed that light was an electromagnetic wave, conveying electromagnetic energy and not mechanical energy as believed by Huygens

He also showed that no medium was necessary for the propagation of electromagnetic waves.

❖ **Quantum theory**

1900, Planck had suggested that energy was emitted and absorbed, not continuously but in multiples of discrete pockets of energy called Quantum which could not be subdivided into smaller parts. In 1905, Einstein extended this idea and suggested

The full shape of a rainbow is Parabola that light waves consist of small pockets of energy called photons. The energy associated with each photon is E = hν, where h is Planck's constant (h = 6.626 × 10^{-34}Js) and ν is the frequency of the electromagnetic radiation. It is now established that photon seems to have a dual character. It behaves as particles in the region of higher energy and as waves in the region of lower energy

Mirror and Lens

Focal Length : - The distance between the pole and the principal focus of a special mirror is called the focal length. (F)

Pole : - The centre of the reflecting surface of a spherical mirror is a point called the pole. It is represented by the letter P.

Radius of Curvature

The radius of the sphere of which the reflecting surface of a spherical mirror forms a part is called the radius of curvature of the mirror (R).

Spherical mirrors of small apertures the radius of curvature is found to be equal to twice the focal length.

R = 2f

Principal Axis :

Imagine a straight line passing through the pole and the centre of curvature of a spherical mirror. This line is called the principal axis.

Lens Mirror	Nature of the image	Size of the Image
Cancave mirror **Convex Lens**	Real and inverted image. Virtual and erect image.	Diminished and enlarged image.
Cancave lens **convex mirror**	Erect virtual	Small image

Uses of Convex Mirrors

1. Rear view mirrors in vehicles, CCTV Camera

Uses of Concave mirrors

1. Tourch Light
2. Street Light

Light is propagated in the form of transverse waves.

3. Vehicles head lights
4. Shaving mirrors
5. Dentists use to see large images of the teeth of patients.
6. Used to concentrate sun light to produce heat in solar turnaces.

Mirror Formula

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

- f = focal length
- u = object distance
- v = image distance

Example - 1

A convex mirror used for rear-view on an automobile has a radius of curvature of 3 m. If a bus is located at 5 m from this mirror, find the position and nature of the image.

Solution:

Radius of curvature, R = +3.00 m

Object distance u = - 5.00 m

Image distance v = ?

We know,

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

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

$$\frac{1}{v} + \frac{1}{1.5} - \frac{1}{-5} = \frac{1}{1.5} + \frac{1}{5} = \frac{15+1.5}{7.5} = \frac{6.5}{7.5}$$

$$= v = \frac{7.5}{6.5} = 1.15 \text{ m}$$

The image is 1.15 m at the back of the mirror. The image is virtual.

Lens formula

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

Example :

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image 10 cm from the lens?

Solution:

v = −10 cm, f = − 15 cm, u = ?

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ (or) } \frac{1}{u} = \frac{1}{v} - \frac{1}{f}$$

$$\frac{1}{u} = \frac{1}{-10} - \frac{1}{-15}$$

$$\frac{1}{u} = \frac{1}{-10} + \frac{1}{15}$$

$$\frac{1}{u} = \frac{-3+2}{30}$$

$$\frac{1}{u} = \frac{-1}{30}$$

u = 30 cm.

Magnification

The magnification produced by a lens is defined as the ratio of the height of the image to the height of the object.

$$M = \frac{v}{u}$$

In fluorescent tube light ultraviolet light is converted into visible light.

Example:

An object is placed at a distance of 30 cm from a concave lens of focal length 15 cm. An erect and virtual image is formed at a distance of 10 cm from the lens. Calculate the magnification.

Solution:

Object distance, u = − 30 cm

Image distance, v = − 10 cm

Magnification, m = v/u

$m = \frac{-10}{-30}$

$m = \frac{1}{3}$

m_2 + 0.33 cm

Power of Lens

The power of lens is defined as the reciprocal of its focal length.

$$P = \frac{1}{f}$$

The S.I unit power of a lens is dioptre. It is denote by the letter D.

Example:

The focal length of a concave lens is 2m. Calculate the power of the lens.

Solution:

Focal length of concave lens, f = − 2 m

Power of the lens,

$p = \frac{1}{f}$

$p = \frac{1}{-2}$

p = − 0.5 dioptre

SOUND

SOUND

- Sound waves can travel through liquids, solids as well as gasses. The substance (solid, liquid or gas) through which sound waves travel is called a medium. Sound waves need a material medium to propagate, they cannot travel through vacuum.
- Robert Boyle, the scientist, proved that sound waves cannot pass through vacuum or empty space.

Wave

- "If the particles of a medium vibrate in a direction, parallel to or along the direction of propagation of wave, it is called a longitudinal wave"
- Sound waves travel in the form of longitudinal waves through gases.
- "If the particles of the medium vibrate in a direction, perpendicular to the direction of propagation, the wave is called a transverse wave."

Definitions of some terms used in relation to waves:

Amplitude (a)

- The maximum displacement of a particle from the mean position is called amplitude. Its unit is metre.

Time period (T)

- Time taken by a particle of the medium to complete one vibration is called Time period. Its unit is second.

Frequency (n)

- The number of vibrations completed by a particle in one second is called frequency. Its unit is hertz. $n = \frac{1}{T}$

Wave Length (λ)

- Distance moved by a wave during the time a particle completes one vibration. Its unit is metre.

Reflection of Sound WAVES

- Echo reflected sound waves reach the ear it can be heard distinctly after the original sound has stopped. This is called an Echo. The sensation of sound persists in our brain for about $1/10^{th}$ of a second. If the reflected sound wave reaches the ear in less than $1/10^{th}$ of a second the brain cannot make out the difference between the original sound and the echo. If the reflected sound wave reaches the ear after $1/10^{th}$ of a second then a distinct echo can be heard. 340 m/s at a temperature of 15°C, sound waves must travel about 34m if it is to be heard as an echo. Therefore, to hear a distinct echo, the surface reflecting the sound should be at least 17 meters away.

Distance = velocity x time

$= 340 \times \frac{1}{10}$

= 34 m. (17 m going and 17 m return)

- Dry air at 0^0C the speed of sound is 331m/s or 750m/h.
- The speed of sound in air, water and steel at 0^0C are
- Air - 331 m/s, water - 1450 m/s, steel - 5000 m/s

The speed of sound

- The Pitch and loudness of sound have no effect on their speed. The speed of sound increases with humidity. Sound travels moist air than in through day air. The speed of sound in air increases by 0.61 metre per second for each degree rise in temperature above 0^oC. The speed of sound depends on the medium. It is more in solids, less in liquids, and the least in gases.

Range of hearing

- Human – 20 to 20000 hertz
- Above 20000hz ultrasonic sound, below 20hz infrasonic sound

Applications of Ultrasound

1. SONAR (Sound Navigation And Ranging)
2. Ultra Sonography 'Ultra sonic waves' can be used to visualize inner organs of the human body.

Reverberation

- The repeated reflection that results in the persistence of sound, often referred to as 'rolling sound' is called reverberation.

Intensity of sound

- The intensity is defined as the amount of energy crossing per unit area per unit time perpendicular to the direction of propagation of the wave. Intensity is measured in Wm^{-2}.

Loudness : The loudness of a sound is related to the energy of the waves and depends on amplitude. The relative loudness of a sound is measured in decibels.

Noise level of 85db or above can impair (or) damage hearing.

Refraction of sound : Sound travels from one medium to another, it undergoes refraction.

Applications of refraction of sound

- It is easier to hear the sound during night than during day-time. During day time, the upper layers of air are cooler than the layers of air near the surface of the Earth. During night, the layers of air near the Earth are cooler than the upper layers of air. As sound travels faster in hot air, during day-time, the sound waves will be refracted upwards and travel a short distance on the surface of the Earth. On the other hand, during night the sound waves are refracted downwards to the Earth and will travel a long distance.

Doppler Effect

- The phenomenon of the apparent change in the frequency of sound due to the relative motion between the source of sound and the observer is called Doppler effect.

- When the source moves towards the stationary observer the pitch sound to increase.
- When the source moves away from the stationary observer the pitch sound appears to decrease.
- When the observer moves towards the stationary source the pitch the sound appears to increase.
- When the observer moves away from the stationary source the pitch of the sound appears to decrease.

Applications of Doppler Effect

1. To measure the speed of an automobile
2. Tracking a satellite
3. Radar (Radio Detection And Ranging)
4. Sonar (Sound Navigation And Ranging)

Amplitude of second wave determines its frequency

ATOMIC & NUCLEAR PHYSICS

ATOMIC PHYSICS

The charge of an electron was found to be 1.602×10^{-19} coulomb.

Properties of Cathode rays

Cathode rays have the following properties:

1. They travel in straight lines.
2. Cathode rays possess momentum and kinetic energy.
3. Cathode rays produce heat, when allowed to fall on matter.
4. Cathode rays produce fluorescence when they strike a number of crystals, minerals and salts.
5. When cathode rays strike a solid substance of large atomic weight, X-rays are produced.
6. Cathode rays ionize the gas through which they pass.
7. Cathode rays affect the photographic plates.
8. The cathode rays are deflected from their straight line path by both electric and magnetic fields. The direction of deflection shows that they are negatively charged particles.
9. Cathode rays travel with a velocity upto $(1/10)^{th}$ of the velocity of light.
10. Cathode rays comprises of electrons which are fundamental constituents of all atoms.

Properties of Canal rays

1. They are the streams of positive ions of the gas enclosed in the discharge tube. The mass of each ion is nearly equal to the mass of the atom.
2. They are deflected by electric and magnetic fields. Their deflection is opposite to that of cathode rays.
3. They travel in straight lines.
4. The velocity of canal rays is much smaller than the velocity of cathode rays.
5. They affect photographic plates.

6. These rays can produce fluorescence.
7. They ionize the gas through which they pass.

Atom models

1803, Dalton, showed that the matter is made up of extremely small particles called atoms. Prout (1815), suggested that all elements are made up of atoms of hydrogen

Thomson atom model

An atom is a sphere of positive charge having a radius of the order of 10^{-10}m. The positive charge is uniformly distributed over the entire sphere and the electrons are embedded in the sphere of positive charge. The total positive charge inside the atom is equal to the total negative charge carried by the electrons, so that every atom is electrically neutral

Rutherford's α - particle scattering experiment

The scattering of the α - particles by a thin gold foil in order to investigate the structure of the atom. An α-particle is a positively charged particle having a mass equal to that of helium atom and positive charge in magnitude equal to twice the charge of an electron.

a. Atom may be regarded as a sphere of diameter 10^{-10}m, but whole of the positive charge and almost the entire mass of the atom is concentrated in a small central core called nucleus having diameter of about 10^{-14}m.
b. The electrons in the atom were considered to be distributed around the nucleus in the empty space of the atom. If the electrons were at rest, they would be attracted and neutralized by the nucleus. To overcome this, Rutherford suggested that the electrons are revolving around the nucleus in circular orbits, so that the centripetal force is provided by the electrostatic force of attraction between the electron and the nucleus.
c. As the atom is electrically neutral, the total positive charge of the nucleus is equal to the total negative charge of the electrons in it.

Bohr atom model

a. An electron cannot revolve round the nucleus in all possible orbits. The electrons can revolve round the nucleus only in those allowed or permissible orbits for which the angular momentum of the electron is an integral multiple of h 2π (where h is Planck's constant = 6.626×10^{-34} Js).

- These orbits are called stationary orbits or nonradiating orbits and an electron revolving in these orbits does not radiate any energy. If m and v are the mass and velocity of the electron in a permitted orbit of radius r then angular momentum of electron = mvr = $\frac{nh}{2\pi}$, where n is called principal quantum number and has the integral values 1,2,3 ... This is called Bohr's quantization condition.

b. An atom radiates energy, only when an electron jumps from a stationary orbit of higher energy to an orbit of lower energy. If the electron jumps from an orbit of energy E2 to an orbit of energy E1, a photon of energy $h\nu = E_2 - E_1$ is emitted. This condition is called Bohr's frequency condition.

$$r_1 = 0.53\text{Å}$$

This is called Bohr radius.

Spectral series of hydrogen atom

Electron in a hydrogen atom jumps from higher energy level to the lower energy level, the difference in energies of the two levels is emitted as a radiation of particular wavelength. It is called a spectral line. As the wavelength of the spectral line depends upon the two orbits (energy levels) between which the transition of electron takes place, various spectral lines are obtained.

(i) Lyman series

When the electron jumps from any of the outer orbits to the first orbit, the spectral lines emitted are in the ultraviolet region

$$\mathbf{n_1 = 1, n_2 = 2, 3...}$$

(ii) Balmer series

When the electron jumps from any of the outer orbits to the second orbit, we get a spectral series called the Balmer series. All the lines of this series in hydrogen have their wavelength in the visible region.

$$\mathbf{n_1 = 2, n_2 = 3, 4...}$$

(iii) Paschen series

This series consists of all wavelengths which are emitted when the electron jumps from outer most orbits to the third orbit This series is in the infrared region

Formula for H2 Series

Wave number $\bar{\lambda} = \left[\frac{1}{n_1{}^2} - \frac{1}{n_2{}^2}\right]$

(iv) Brackett series

The series obtained by the transition of the electron from n_2 = 5, 6... to n_1 = 4 is called Brackett series. The wavelengths of these lines are in the infrared region.

(v) Pfund series

The lines of the series are obtained when the electron jumps from any state n_2 = 6, 7... to n_1=5. This series also lies in the infrared region.

Excitation and ionization potential of an atom

The energy required to raise an atom from its normal state into an excited state is called excitation potential energy of the atom. Hydrogen atom, the energy required to remove an electron from first orbit to its outermost orbit(n=∞) 13.6-0=13.6eV. This energy is known as the ionization potential energy for hydrogen atom

Sommerfeld atom model

In order to explain the observed fine structure of spectral lines, Sommerfeld introduced two main modifications in Bohr's theory.

(i) According to Sommerfeld, the path of an electron around the nucleus, in general, is an ellipse with the nucleus at one of its foci.

(ii) The velocity of the electron moving in an elliptical orbit varies at different parts of the orbit. This causes the relativistic variation in the mass of the moving electron

X–rays

A German scientist, Wilhelm Roentgen, in 1895, discovered X–rays X-rays are electromagnetic waves of short wavelength in the range of 0.5 Å to 10 Å. Roentgen was awarded Nobel prize in 1901 for the discovery of X–rays

Production of X–rays – Modern Coolidge tube

X–rays are produced, when fast moving electrons strike a metal target of suitable material. The basic requirement for the production of X–rays are: (i) a source of electrons, (ii) effective means of accelerating the electrons and (iii) a target of suitable material of high atomic weight.

Soft X–rays and Hard X–rays

X–rays are of two types : (i) Soft X–rays and (ii) Hard X–rays

(i) Soft X–rays

X–rays having wavelength of 4Å or above, have lesser frequency and hence lesser energy. They are called soft X – rays due to their low penetrating power. They are produced at comparatively low potential difference.

(ii) Hard X–rays

X–rays having low wavelength of the order of 1Å have high frequency and hence high energy. Their penetrating power is high, therefore they are called hard X–rays. They are produced at comparatively high potential difference.

Properties of X–rays

1. X–rays are electromagnetic waves of very short wave length. They travel in straight lines with the velocity of light. They are invisible to eyes.
2. They undergo reflection, refraction, interference, diffraction and polarisation.
3. They are not deflected by electric and magnetic fields. This indicates that X-rays do not have charged particles.
4. They ionize the gas through which they pass.
5. They affect photographic plates.
6. X–rays can penetrate through the substances which are opaque to ordinary light e.g. wood, flesh, thick paper, thin sheets of metals.
7. When X–rays fall on certain metals, they liberate photo electrons (Photo electric effect).
8. X-rays have destructive effect on living tissue. When the human body is exposed to X-rays, it causes redness of the skin, sores and serious injuries to the tissues and glands. They destroy the white corpuscles of the blood.
9. X–rays do not pass through heavy metals such as lead and bones. If such objects are placed in their path, they cast their shadow

Applications of X–rays

X–rays have a number of applications. Some of them are listed below:

Medical applications

- X–rays are being widely used for detecting fractures, tumours, the presence of foreign matter like bullet etc., in the human body.
- X–rays are also used for the diagnosis of tuberculosis, stones in kidneys, gall bladder etc.
- Many types of skin diseases, malignant sores, cancer and tumours have been cured by controlled exposure of X-rays of suitable quality.
- Hard X–rays are used to destroy tumours very deep inside the body.

Industrial applications

a. X–rays are used to detect the defects or flaws within a material

b. X–rays can be used for testing the homogeneity of welded joints, insulating materials etc.

c. X-rays are used to analyse the structure of alloys and the other composite bodies.

d. X–rays are also used to study the structure of materials like rubber, cellulose, plastic fibres etc.

Scientific research

1. X–rays are used for studying the structure of crystalline solids and alloys.
2. X–rays are used for the identification of chemical elements including determination of their atomic numbers.
3. X–rays can be used for analyzing the structure of complex molecules by examining their X–ray diffraction pattern.

Laser

Some sources have been developed, which are highly coherent known as LASER. The word ‘Laser’ is an acronym for Light Amplification by Stimulated Emission of Radiation.

Characteristics of laser

The laser beam (i) is monochromatic. (ii) is coherent, with the waves, all exactly in phase with one another, (iii) does not diverge at all and (iv) is extremely intense

Applications of laser

Due to high coherence, high intensity, laser beams have wide applications in various branches of science and engineering.

Industrial applications

a. The laser beam is used to drill extremely fine holes in diamonds, hard sheets etc.,
b. They are also used for cutting thick sheets of hard metals and welding.
c. The laser beam is used to vapourize the unwanted material during the manufacture of electronic circuit on semiconductor chips.
d. They can be used to test the quality of the materials.

Medical applications

a. In medicine, micro surgery has become possible due to narrow angular spread of the laser beam.
b. It can be used in the treatment of kidney stone, tumour, in cutting and sealing the small blood vessels in brain surgery and retina detachment.
c. The laser beams are used in endoscopy.
d. It can also be used for the treatment of human and animal cancer.

Scientific and Engineering applications

1. Since the laser beam can stay on at a single frequency, it can be modulated to transmit large number of messages at a time in radio, television and telephone.
2. The semiconductor laser is the best light source for optical fiber communication.
3. Narrow angular spread of the laser beam makes it a very useful tool for microwave communication. Communication with earth satellites and in rocketry. Laser is also used in accurate range finders for detecting the targets.
4. The earth-moon distance has been measured with the help of lasers.
5. It is used in laser Raman Spectroscopy.

6. Laser is also used in holography (three dimensional lensless photography)
7. Laser beam can determine precisely the distance, velocity and direction as well as the size and form of the objects by means of the reflected signal as in radar.

Holography

- A three dimensional image of an object can be formed by holography. In ordinary photography, the amplitude of the light wave is recorded on the photographic film. In holography, both the phase and amplitude of the light waves are recorded on the film. The resulting photograph is called hologram.

MASER

- The term MASER stands for Microwave Amplification by Stimulated Emission of Radiation. The working of maser is similar to that of laser.

NUCLEAR PHYSICS

Nuclear Physics

- The atomic nucleus was discovered by Earnest Rutherford in 1911. Rutherford's experiment on scattering of alpha particles proved that the mass of the atom and the positive charge is concentrated in a very small central core called nucleus. The dimension of nucleus is much smaller than the overall dimension of the atom. The nucleus is surrounded by orbiting electrons.

Nucleus

- The nucleus consists of the elementary particles, protons and neutrons which are known as nucleons. A proton has positive charge of the same magnitude as that of electron and its rest mass is about 1836 times the mass of an electron. A neutron is electrically neutral, whose mass is almost equal to the mass of the proton. The nucleons inside the nucleus are held together by strong attractive forces called nuclear forces.
- A nucleus of an element is represented as $_ZX^A$, where X is the chemical symbol of the element. Z

represents the atomic number which is equal to the number of protons and A, the mass number which is equal to the total number of protons and neutrons. The number of neutrons is represented as N which is equal to A–Z. For example, the chlorine nucleus is represented as $_{17}Cl^{35}$. It contains 17 protons and 18 neutrons.

Classification of nuclei

(i) Isotopes

- Isotopes are atoms of the same element having the same atomic number Z but different mass number A. The nuclei $_1H^1$, H^2 and H^3 are the isotopes of hydrogen. In other words isotopes of an element contain the same number of protons but different number of neutrons. As the atoms of isotopes have identical electronic structure, they have identical chemical properties

(ii) Isobars

- Isobars are atoms of different elements having the same mass number A, but different atomic number Z. The nuclei $_8O^{16}$ and $_7N^{16}$ represent two isobars. Since isobars are atoms of different elements, they have different physical and chemical properties.

(iii) Isotones

- Isotones are atoms of different elements having the same number of neutrons. $_6C^{14}$ and $_8O^{16}$ are some examples of isotones.

General properties of nucleus

Nuclear size

- measure of nuclear radius, which is approximately 10^{-15}m.
  (1 Fermi, F = 10^{-15}m)

Nuclear density

The nuclear density is calculated as 1.816×10^{17} kg m^{-3}

Nuclear charge

Proton has a positive charge equal to 1.6×10^{-19}C.

Atomic mass unit

- One atomic mass unit is considered as one twelfth of the mass of carbon atom $_6C^{12}$. Carbon of atomic number 6 and mass number 12 has mass equal to 12 amu.

$$1 \text{ amu} = 1.66 \times 10^{-27} \text{kg}$$

The mass of a proton, mp = 1.007276

1 amu = 931 MeV

Binding energy

Explanation of binding energy curve

- The binding energy per nucleon increases sharply with mass number A upto 20. It increases slowly after A = 20. For A<20, there exists recurrence of peaks corresponding to those nuclei, whose mass numbers are multiples of four and they contain not only equal but also even number of protons and neutrons. Example: He4, $_4Be^8$, C^{12}, $_8O^{16}$, and $_{10}Ne^{20}$. The curve becomes almost flat for mass number between 40 and 120. Beyond 120, it decreases slowly as A increases.
- The binding energy per nucleon reaches a maximum of 8.8 MeV at A=56, corresponding to the iron nucleus ($_{26}Fe^{56}$). Hence, iron nucleus is the most stable.
- The average binding energy per nucleon is about 8.5 MeV for nuclei having mass number ranging between 40 and 120. These elements are comparatively more stable and non radioactive.
- For higher mass numbers the curve drops slowly and the BE/A is about 7.6 MeV for uranium. Hence, they are unstable and radioactive.
- The lesser amount of binding energy for lighter and heavier nuclei explains nuclear fusion and fission respectively. A large amount of energy will be liberated if lighter nuclei are fused to form heavier one (fusion) or if heavier nuclei are split into lighter ones (fission).

Nuclear force

1. Nuclear force is charge independent. It is the same for all the three types of pairs of nucleons (n–n), (p–p) and (n–p). This shows that nuclear force is not electrostatic in nature
2. Nuclear force is the strongest known force in nature.
3. Nuclear force is not a gravitational force. Nuclear force is about 10^{40} times stronger than the gravitational force.
4. Nuclear force is a short range force. It is very strong between two nucleons which are less than 10^{-15} m apart and is almost

negligible at a distance greater than this. On the other hand electrostatic, magnetic and gravitational forces are long range forces that can be felt easily. Yukawa suggested that the nuclear force existing between any two nucleons may be due to the continuous exchange of particles called mesons, just as photons, the exchange particle in electromagnetic interactions. However, the present view is that the nuclear force that binds the protons and neutrons is not a fundamental force of nature but it is secondary.

Radioactivity

- Radioactivity was discovered by Henri Becquerel in 1896 The phenomenon of spontaneous emission of highly penetrating radiations such as α, β and γ rays by heavy elements having atomic number greater than 82 is called radioactivity and the substances which emit these radiations are called radioactive elements The radioactive phenomenon is spontaneous and is unaffected by any external agent like temperature, pressure, electric and magnetic fields etc.

Properties of α–rays

1. An α - particle is a helium nucleus consisting of two protons and two neutrons. It carries two units of positive charge.
2. They move along straight lines with high velocities.
3. They are deflected by electric and magnetic fields.
4. They produce intense ionisation in the gas through which they pass. The ionising power is 100 times greater than that of β-rays and 10,000 times greater than that of γ–rays.
5. They affect photographic plates.
6. They are scattered by heavy elements like gold.
7. They produce fluorescence when they fall on substances like zinc sulphide or barium platinocyanide.

Properties of β – rays

1. β–particles carry one unit of negative charge and mass equal to that of electron.Therefore, they are nothing but electrons.
2. The β–particles emitted from a source have velocities over the range of 0.3 c to 0.99 c, where c is the velocity of light.
3. They are deflected by electric and magnetic fields.
4. The ionisation power is comparatively low
5. They affect photographic plates.
6. They penetrate through thin metal foils and their penetrating power is greater than that of α–rays
7. They produce fluorescence when they fall on substances like barium platinocyanide.

Properties of γ – rays

1. They are electromagnetic waves of very short wavelength.
2. They are not deflected by electric and magnetic fields.
3. They travel with the velocity of light.
4. They produce very less ionisation.
5. They affect photographic plates.
6. They have a very high penetrating power, greater than that of β-rays.
7. They produce fluorescence.
8. They are diffracted by crystals in the same way like X–rays are diffracted.

Half life period

- Since all the radioactive elements have infinite life period, in order to distinguish the activity of one element with another, half life period and mean life period are introduced. The half life period of a radioactive element is defined as the time taken for one half of the radioactive element to undergo disintegration.

From the law of disintegration

$$N = N_o e^{-\lambda t}$$

The half life and mean life are related as

$T_{1/2} = \frac{0.6931}{\lambda}$

$T_{1/2} = 0.6931\tau$

Neutron

Chadwick in the discovered that the emitted radiation consists of particles of mass nearly equal to proton and no charge.

$$_4Be^9 + _2He^4 \rightarrow _6C^{12} + _0n^1$$

where $_0n^1$ represents neutron

Properties of neutrons

1. Neutrons are the constituent particles of all nuclei, except hydrogen.
2. Neutrons are neutral particles with no charge and mass slightly greater than that of protons. Hence, they are not deflected by electric and magnetic fields.
3. Neutrons are stable inside the nucleus. But outside the nucleus they are unstable. The free neutron decays with an emission of proton, electron and antineutrino, with half life of 13 minutes. $_0n^1 \rightarrow _1H^1 + _{-1}e^0 + \bar{\nu}$
4. As neutrons are neutral, they can easily penetrate any nucleus.
5. Neutrons are classified according to their kinetic energy as (a) slow neutrons and (b) fast neutrons. Both are capable of penetrating a nucleus causing artificial transmutation of the nucleus. Neutrons with energies from 0 to 1000 eV are called slow neutrons. The neutrons with an average energy of about 0.025 eV in thermal equilibrium are called thermal neutrons. Neutrons with energies in the range between 0.5 MeV and 10 MeV are called fast neutrons. In nuclear reactors, fast neutrons are converted into slow neutrons using moderators.

Artificial radioactivity

- Artificial radioactivity or induced radioactivity was discovered by Irene Curie and F. Joliot in 1934. This is also known as man-made Radioactivity

Applications of radio-isotopes

Medical applications

- In medical field, radio-isotopes are used both in diagnosis and therapy. Radio cobalt (Co^{60}) emitting γ–rays is used in the treatment of cancer. Gamma rays destroy cancer cells to a greater extent. Radio-sodium (Na^{24}) is used to detect the presence of blocks in blood vessels, to check the effective functioning of heart in pumping blood and maintaining circulation. Radio-iodine (I^{131}) is used in the detection of the nature of thyroid gland and also for treatment. Radioiodine is also used to locate brain tumours. Radio-iron (Fe^{59}) is used to diagnose anaemia. An anaemic patient retains iron in the blood longer than normal patient. Radio-phosphorous (P^{32}) is used in the treatment of skin diseases.

(ii) Agriculture

- In agriculture, radio-isotopes help to increase the crop yields. Radio-phosphorous (P^{32}) incorporated with phosphate fertilizer is added to the soil. The plant and soil are tested from time to time. Phosphorous is taken by the plant for its growth and radio-phosphorous is found to increase the yield.
- Sprouting and spoilage of onions, potatoes, grams etc. are prevented by exposure to a very small amount of radiation. Certain perishable cereals remain fresh beyond their normal life span when exposed to radiation.

(iii) Industry

- In Industry, the lubricating oil containing radio-isotopes is used to study the wear and tear of the machinery.

(iv) Molecular biology

- In molecular biology radio-isotopes are used in sterilizing pharmaceutical and surgical instruments.

(v) Radio-carbon dating

- In the upper atmosphere, C_{14} is continually formed from N_{14} due to the bombardment by neutrons produced from cosmic rays.

$$_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14*} + {}_1H^1$$

- The C_{14} is radioactive with half life of 5570 years. The production and the decay of C_{14} are in equilibrium in atmosphere. The ratio of C_{14} and C_{12} atoms in atmosphere is $1 : 10^6$. Hence, carbon dioxide present in the atmosphere contains a small portion of C_{14}.
- Living things take C_{14} from food and air. However with death, the intake of C_{14} stops, and the C_{14} that is already present begins to decay. Hence the amount of C_{14} in the sample will enable the

calculation of time of death i.e, the age of the specimen could be estimated. This is called radio-carbon dating. This method is employed in the dating of wooden implements, leather clothes, charcoal used in oil paintings, mummies and so on.

Biological hazards of nuclear radiations

- When γ-ray or any high energy nuclear particle passes through human beings, it disrupts the entire normal functioning of the biological system and the effect may be either pathological or genetic. The biological effects of nuclear radiation can be divided into three groups

(i) Short term recoverable effects

(ii) Long term irrecoverable effects and

(iii) Genetic effect

The extent to which the human organism is damaged depends upon

(i) The dose and the rate at which the radiation is given and

(ii) The part of the body exposed to it.

Smaller doses of radiation exposure produce short term effects such as skin disorder and loss of hair. If the exposure is 100 R*, it may cause diseases like leukemia (death of red blood corpuscle in the blood) or cancer. When the body is exposed to about 600 R, ultimately it causes death. Safe limit of receiving the radiations is about 250 milli roentgen per week. The genetic damage is still worse. The radiations cause injury to genes in the reproductive cells. This gives rise to mutations which pass on from generation to generation. The following precautions are to be taken for those, who are working in radiation laboratories.

1. Radioactive materials are kept in thick–walled lead container.
2. Lead aprons and lead gloves are used while working in hazardous area.
3. All radioactive samples are handled by a remote control process.
4. A small micro–film badge is always worn by the person and it is checked periodically for the safety limit of radiation.

The radiation exposure is measured by the unit called roentgen (R). One roentgen is defined as the quantity of radiation which produces 1.6×10^{12} pairs of ions in 1 gram of air.

Nuclear fission

- In 1939, German scientists Otto Hahn and F. Strassman discovered that when uranium nucleus The process of breaking up of the nucleus of a heavier atom into two fragments with the release of large amount of energy is called nuclear fission.

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q$$

- Atom bomb is based on the principle of uncontrolled fission chain reaction. Natural uranium consists of 99.28% of U^{238} and 0.72% of U^{235}. U^{238} is fissionable only by fast neutrons. Hence, it is essential in a bomb that either U^{235} or Pu^{239} should be used, because they are fissionable by neutrons of all energies

Nuclear reactor

- A nuclear reactor is a device in which the nuclear fission reaction takes place in a self sustained and controlled manner. The first nuclear reactor was built in 1942 at Chicago USA

Fissile material or fuel

- The fissile material or nuclear fuel generally used is $_{92}U^{235}$. But this exists only in a small amount (0.7%) in natural uranium. Natural uranium is enriched with more number of $_{92}U^{235}$ (2 – 4%) and this low enriched uranium is used as fuel in some reactors. Other than U^{235}, the fissile isotopes U^{233} and Pu^{239} are also used as fuel in some of the reactors.

Moderator

- The function of a moderator is to slow down fast neutrons produced in the fission process having an average energy of about 2 MeV to thermal neutrons with an average energy of about 0.025 eV, which are in thermal equilibrium with the moderator. Ordinary water and heavy water are the commonly used moderators Graphite is also used as a moderator in some countries. In fast breeder reactors, the fission chain reaction is sustained by fast neutrons and hence no moderator is required.

Neutron source

- A mixture of beryllium with plutonium or radium or polonium is commonly used as a source of neutron

Control rods

- The control rods are used to control the chain reaction. They are very good absorbers of neutrons. The commonly used control rods are made up of elements like boron or cadmium In our country, all the power reactors use boron carbide (B_4C), a ceramic material as control rod.

The cooling system

- The cooling system removes the heat generated in the reactor core. Ordinary water, heavy water and liquid sodium are the commonly used coolants. A good coolant must possess large specific heat capacity and high boiling point. Liquid sodium boiling point is about 1000^{0} C.

Neutron reflectors

Neutron reflectors prevent the leakage of neutrons to a large extent, by reflecting them back

Uses of reactors

a. Nuclear reactors are mostly aimed at power production, because of the large amount of energy evolved with fission.
b. Nuclear reactors are useful to produce radio-isotopes
c. Nuclear reactor acts as a source of neutrons, hence used in the scientific research

Nuclear fusion

- Nuclear fusion is a process in which two or more lighter nuclei combine to form a heavier nucleus. The mass of the product nucleus is always less than the sum of the masses of the individual lighter nuclei. The difference in mass is converted into energy. The fusion process can be carried out only at a extremely high temperature of the order of 10^7 K

The nuclear fusion reactions are known as thermo-nuclear reactions

Hydrogen bomb

- The principle of nuclear fusion is used in hydrogen bomb. It is an explosive device to release a very large amount of energy by the fusion of light nuclei.

$${}_1H^3 + {}_1H^2 \rightarrow {}_2He^4 + {}_0n^1 + \text{energy}$$

Elementary particles

The study of the structure of atom reveals that the fundamental particles electron, proton and neutron are the building blocks of an atom. But the extensive studies on cosmic rays have revealed the existence of numerous new nuclear particles like mesons. These particles are classified into four major groups as photons, leptons mesons and baryons.

The heavy water project is located at Tuticorin.