PHYSICS

BRIDGE COURSE MODULE

2022

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Introduction to Science

Science

Systematic knowledge based on facts, experiments and observations is called **Science.**

The **branches of science** are commonly divided into three major groups:

1. **Formal or Abstract science**: Study of relationship of magnitude and numbers.

Examples: Mathematics, Statistics etc.

2. **Social science**: Study of social activities of man based on tradition sand reasoning.

Examples: Sociology, Political Science, Economics etc.

3. **Natural science**: Study of facts of the nature .It is also called basic science. Natural science is divided into two fields on the basis of their nature of study- **Physical science** and **Biological science.**

Physical science: It is the study of non-living things and natural phenomena governed by a set of laws. Examples: Physics, Chemistry, Astronomy etc.

Biological science: The Study of living things. It is also called life science or biology. Examples: Botany, Zoology, Ecology etc.

Physics

Physics is a branch of science that deals with the properties of matter and energy and the relationship between them. It also explains about the material world and the natural phenomena of the universe.

The branches of Physics are as follows:

1. Classical physics
2. Modern physics
3. Nuclear physics
4. Atomic physics
5. Geophysics
6. Biophysics
7. Mechanics
8. Acoustics
9. Optics
10. Thermodynamics
11. Astrophysics

- Classical Physics is a branch of physics deals mostly with matter and energy.
- Modern physics is a branch of physics that is mainly concerned with the theory of relativity and quantum mechanics.
- Nuclear physics is a branch of physics that deals with the constituents, structure, behavior and interactions of atomic nuclei.
- Atomic physics is a branch of physics that deals with the composition of the atom apart from the nucleus.
- Geophysics is a branch of physics that deals with the study of the Earth.
- Biophysics studies biological problems and the structure of molecules in living organisms using techniques derived from physics.
- Mechanical physics is a branch of physics that deals with the motion of material objects under the influence of forces.
- Acoustics is a branch of physics that studies how sound is produced, transmitted, received and controlled.
- Optics is a branch of physics that studies electromagnetic radiation (for example, light and infrared radiation), its interactions with matter, and instruments used to gather information due to these interactions.
- Thermodynamics is a branch of physics that deals with heat and temperature and their relation to energy and work. The behavior of these quantities is governed by the four laws of thermodynamics.
- Astrophysics is a branch of astronomy which is concerned with the study of universe (i.e., stars, galaxies, and planets) using the laws of physics.

1.UNITS AND DIMENSIONS

Unit of Measurement

The laws of physics are expressed in terms of physical quantities such as distance, speed, time, force, volume, electric current, etc. For measurement, each physical quantity is assigned a unit. For example, time could be measured in minutes, hours or days.

The reference standard of measurement of physical quantity is called **Unit**.

The unit chosen should have the following properties-

1. The unit should be of convenient size.

2. It should be well defined.

3. The unit should be reproducible.

4. The value of the unit should not change with space and time.

5. It should be accepted internationally.

Units are of two kinds:

1**. Fundamental units**

2**. Derived units**

A **fundamental unit** is that which is independent of any other unit or which can neither be changed nor can be related to any other fundamental unit.

Examples: unit mass, length, time etc.

Derived units are those which depend on the fundamental units or which can be expressed in terms of the fundamental units.

Examples: speed, velocity, force etc.

The SI units

The name SI is abbreviation for **Systeme International d'Unites** for the International System of units. The system is popularly known as the metric system. The Fundamental SI units along with their symbols are given in the table.

1.	Length (l)	Meter	m
2.	Mass (M)	Kilogram	kg
3.	Time (T)	Second	s
4.	Electric current (I)	Ampere	A
5.	Thermodynamic temperature (Θ)	Kelvin	K
6.	Amount of substance (N)	Mole	mol
7.	Luminous intensity (I_v)	Candela	cd

Derived SI Units List

For many quantities, we need units which we get by combining the basic units. These units are called derived units.

Sl. No	Unit(s) Name	SI Unit	SI Unit Symbol
1.	Force, Weight	Newton	N
2.	Frequency	Hertz	Hz
3.	Electric charge	Coulomb	C
4.	Electric potential (Voltage)	Volt	V
5.	Inductance	Henry	H
6.	Capacitance	Farad	F
7.	Resistance, Impedance, Reactance	Ohm	Ω
8.	Electrical conductance	Siemens	S
9.	Magnetic flux	Weber	Wb
10.	Magnetic flux density	Tesla	T
11.	Energy, Work, Heat	Joule	J
12.	Power, Radiant flux	Watt	W
13.	Angle	Radian	rad
14.	Radioactivity	Becquerel	Bq
15.	Luminous flux	Lumen	lm

Dimensions

Dimensions of a physical quantity are the powers to which the fundamental units are raised to obtain one unit of that quantity.

Dimensional Formula: The expression showing the powers to which the fundamental units are to be raised to obtain one unit of a derived quantity is called the **dimensional formula** of that quantity.

If Q is the unit of a derived quantity represented by Q = $M^aL^bT^c$, then $M^aL^bT^c$ is called dimensional formula and the exponents a, b and, c are called the dimensions.

Physical quantity	**Unit**	**Dimensional formula**
Acceleration or acceleration due to gravity	ms^{-2}	LT^{-2}
Angular frequency (angular displacement/time)	$rads^{-1}$	T^{-1}
Angular momentum (Iω)	kgm^2s^{-1}	ML^2T^{-1}
Angular velocity (angle/time)	$rads^{-1}$	T^{-1}
Calorific value	Jkg^{-1}	L^2T^{-2}
Density (mass / volume)	kgm^{-3}	ML^{-3}
Displacement, wavelength, focal length	m	L
Electric charge or quantity of electric charge (current x time)	coulomb	IT
Electric current	ampere	I
Emf (or) electric potential (work/charge)	volt	$ML^2T^{-3}I^{-1}$
Energy (capacity to do work)	joule	ML^2T^{-2}
Force (mass x acceleration)	Newton (N)	MLT^{-2}
Impulse (force x time)	Ns or $kgms^{-1}$	MLT^{-1}
Intensity of gravitational	Nkg^{-1}	L^1T^{-2}

field (F/m)		
Linear density (mass per unit length)	kgm^{-1}	ML^{-1}
Luminous flux	lumen or (Js^{-1})	ML^2T^{-3}
Magnetic dipole moment	Am^2	L^2I
Magnetic flux (magnetic induction x area)	Weber (Wb)	$ML^2T^{-2}I^{-1}$
Magnetic induction (F = Bil)	$NI^{-1}m^{-1}$ or T	$MT^{-2}I^{-1}$
Moment of inertia (mass x radius^2)	kgm^2	ML^2
Momentum (mass x velocity)	$kgms^{-1}$	MLT^{-1}
Power (work/time)	Js^{-1} or watt (W)	ML^2T^{-3}
Pressure (force/area)	Nm^{-2} or Pa	$ML^{-1}T^{-2}$
Speed (distance/time)	ms^{-1}	LT^{-1}
Stress (restoring force/area)	Nm^{-2} or Pa	$ML^{-1}T^{-2}$
Surface energy density (energy/area)	Jm^{-2}	MT^{-2}
Time period	second	T
Velocity (displacement/time)	ms^{-1}	LT^{-1}

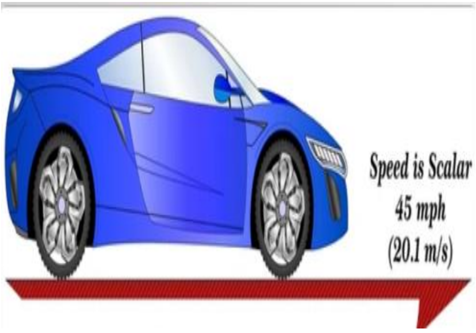
Scalars and Vectors

On the basis of direction, the physical quantities may be divided into two main classes: **Scalar Quantities** and **Vector Quantities**.

A **scalar quantity** is defined as the physical quantity with only magnitude and no direction. Such physical quantities can be described just by their numerical value without directions. The addition of these physical quantities follows the simple rules of algebra, and here, only their magnitudes are added.

Some examples of **scalar** quantity include:

- Mass
- Speed
- Distance
- Time
- Volume
- Density
- Temperature

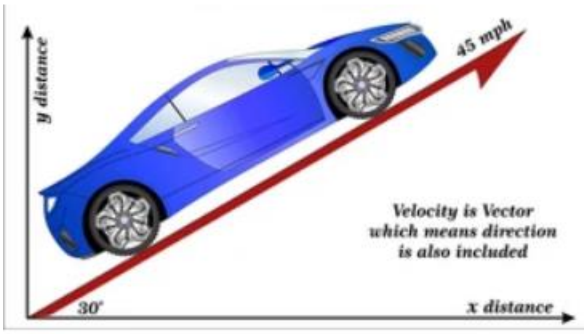


A vector quantity is defined as the physical quantity that has both directions as well as magnitude.

A vector with the value of magnitude equal to one is called a unit vector and is represented by a lowercase alphabet with a "hat" circumflex i.e. "**û**".

Examples of **vector** quantity include:

- Linear momentum
- Acceleration
- Displacement
- Momentum
- Angular velocity
- Force
- Electric field



<u>Scalar Field</u>

A scalar field is an assignment of a scalar to each point in region in the space. E.g. the temperature at a point on the earth is a scalar field. A vector field is an assignment of a vector to each point in a region in the space.

<u>Vector Field</u>

A vector field is an assignment of a vector to each point in a subset of space. For instance, a vector field in the plane can be visualised as a collection of arrows with a given magnitude and direction, each attached to a point in the plane.

2.MECHANICS

Mechanics is the branch of physics which deals with the study of motion material objects, having three branches called **kinematics, statics and dynamics**.

Kinetics is the study of the motion of the object without taking into account the cause of motion.

Statistics is the study of object at rest.

Dynamics is the study of motion of object taking into account the factors which cause motion, whereas a body is said to be in motion if its position changes with time otherwise the body is said to be rest.

Distance is the total length of the actual path covered by a body while speed is the distance covered by a moving body in a certain interval of time.

Displacement is the net change in the position of a body in a certain interval of time with respect to a fixed point, whereas velocity is the rate of change of displacement of a body.

Difference between Distance and Displacement

S .No.	Distance	Displacement
1.	It is actual path traversed by the object in the given time.	It is shortest distance between initial and final positions of the object in given time.
2.	It is a scalar quantity.	It is a vector quantity.
3.	It is always positive.	It is positive, zero or negative depending on direction.
4.	It can be more than or equal to the magnitude of displacement.	Its magnitude can be less than or equal to the distance, but can never be greater than the distance.
5.	It may not be zero even if displacement is zero.	It is zero if distance is zero.

Speed: The speed of a body is the distance travelled by a body in a unit time interval ,i.e., it is the distance travelled by the body in 1s.If a body travels a distance **s** in time **t**, then it is known as speed.

Speed=Distance/Time

Velocity: The rate of change of displacement with time is called velocity i.e., it is the displacement of the body in 1s.

Velocity=displacement/time

Difference between speed and velocity

S. No.	Speed	Velocity
1.	The distance travelled by a moving object in one second is called its speed.	The distance travelled by a moving object in one second in a particular direction is called its velocity.
2.	It is a scalar quantity.	It is a vector quantity.
3.	The speed is always positive.	The velocity can be positive or negative depending on the direction of motion.

The Forces and Laws of Motion

Force can be defined as push or pull on an object.

Force is an external agent capable of changing the state of rest or motion of a particular body. It has a magnitude and a direction. The direction towards which the force is applied is known as the direction of the force and the application of force is the point where force is applied.

The Force has different effects and here are some of them.

- Force can make a body that is at rest to move.
- It can stop a moving body or slow it down.
- It can accelerate the speed of a moving body.
- It can also change the direction of a moving body along with its shape and size.

The Four Fundamental Forces and their strengths

1. Gravitational Force – Weakest force; but has infinite range.
2. Weak Nuclear Force – Next weakest; but short range.
3. Electromagnetic Force – Stronger, with infinite range.
4. Strong Nuclear Force – Strongest; but short range.

Gravitational Force

- The gravitational force is weak but very long-ranged.
- Furthermore, it is always attractive.
- It acts between any two pieces of matter in the Universe since mass is its source.

Nuclear Force

- The weak force is responsible for radioactive decay and neutrino interactions.
- It has a very short range and.
- As its name indicates, it is very weak.
- The weak force causes Beta-decay i.e., the conversion of a neutron into a proton, an electron and an antineutrino.

Electromagnetic Force

- The electromagnetic force causes electric and magnetic effects such as the repulsion between like electrical charges or the interaction of bar magnets.

- It is long-ranged but much weaker than the strong force.

- It can be attractive or repulsive and acts only between pieces of matter carrying an electrical charge. Electricity, magnetism, and light are all produced by this force.

Strong Nuclear Force

- The strong interaction is very strong but very short-ranged.

- It is responsible for holding the nuclei of atoms together.

- It is basically attractive but can be effectively repulsive in some circumstances. The strong force is 'carried' by particles called gluons; that is, when two particles interact through the strong force, they do so by exchanging gluons.

- Thus, the quarks inside of the protons and neutrons are bound together by the exchange of the strong nuclear force.

Motion along a straight line is known as linear motion while motion along a circle of certain radius is known as circular motion. The motion of a body along curved line is called angular motion. The force towards the centre of circular motion which is necessary to bound the motion of a particle on the circular path, is radially inward force to a body and it is called centripetal force, whereas centrifugal force is radially outward force which just opposite to centripetal force.

Newton's First Law:

If a body is at rest then it will remain at rest or if it is moving along a straight line with uniform speed then it will continue to move as such unless an external force is applied on it to change its present state.

This property of bodies showing a reluctance to change their present state is called "**inertia**".

Hence, Newton's first law is also known as the **"law of inertia"**.

Mass of a body is a measure of its inertia.

Newton's Second Law:

This law tells us what happens to the state of rest or of uniform motion of a body when a net external forces acts on the body i.e., when the body interacts with other surroundings bodies.

This law states –"The rate of change of linear momentum of a particle is directly proportional to the force applied on the particle and it takes place in the direction of the force".

Newton' second law is also known as "**Law of change in momentum**".

Newton's Third Law:

The two forces involved in every interaction between the bodies are called action and a reaction. Either force may be considered as 'action' and the other the 'reaction'. This fact was made clear in Newton's third law of motion.

This law states -"To every action there is always an equal and opposite reaction".

Newton's third law deals with two forces, each acting on a different body. This law is also known as **"Law of action-reaction"**.

If the sum of all the external forces acting on a body is zero, the change in momentum of the body will be zero. This is law of conservation of momentum, rocket propulsion and jet engine work on this law of conservation of momentum.

If an external force is acting on a body for a very short time, then the product of this external force and time is known as impulse and the force itself is called impulsive force.

GRAVITATION

Force of attraction between two objects is directly proportional to the product of their masses and inversely proportional to the square of distance between them i.e.,

$$F=G\, m_1\, m_2/r^2.$$

This is called Newton's law of gravitation, where G is known as Universal Gravitation constant.

The acceleration produced in a body due to force of gravity is called acceleration due to gravity (g).Its value is $9.8 m/s^2$.At the surface of the earth, it is minimum at Equator and maximum at poles. The value of g on the moon's surface is $1/6^{th}$ of the value of g on the Earth's surface.

The space surrounding the material body in which its gravitational force of attraction can be experienced is called gravitational field and work done in carrying a unit mass from infinity to a point in gravitational field is called its Gravitational Potential.

Kepler's Laws

Every planet revolves around the Sun in an elliptical orbit with the Sun at its one of the foci. This is Kepler's first law. The line joining the planet to the Sun sweeps out equal area in equal interval of time. This Kepler's second law. And the square of the period of revolution of any planet about the Sun is directly proportional to the cube of the semi-major axis of the elliptical orbit. This is Kepler's third law. The heavenly bodies revolving around the Sun are called Planets and the heavenly bodies revolving around the planets are called satellite.

WORK, POWER AND ENERGY

When a body is displaced by applying a force on it, then work is said to be done. It is a scalar quantity having SI unit Joule (J).

Power is measured as the rate of doing work. It is a scalar quantity having SI unit J/s or Watt (w).

Energy is the ability to do work. The SI unit of energy is Joule.

Law of Conservation of Energy

According to the **law of conservation** of energy it states that "the energy can neither be created nor destroyed but can only be converted from one form to another".

Energy exists in many forms and they can be converted from one form to another. Although there are many types of energy such as gravitational energy, atomic energy and so on, there are only two major forms of energy known as **potential energy** and **kinetic energy**.

Kinetic energy is the energy in moving objects.
Examples: mechanical energy and electrical energy.

Potential energy is the energy stored in objects that can be used for future use.
Examples: chemical energy and nuclear energy.

The five major types of energy:

- **Electrical Energy**
  The energy carried by moving electrons in a conductor is known as an electrical energy. The natural source of electrical energy is the lightning.

- **Chemical Energy**
  Chemical energy is the energy stored in the bonds of chemical compounds.

- **Mechanical Energy**
  Mechanical energy is the energy in an object due to its motion.

- **Thermal Energy**
  Thermal energy is the energy a substance or system has related to its temperature.

- **Nuclear Energy**
  The energy trapped inside each atom is known as a nuclear energy.

Energy Conversion: Transfer and Transform

We know the energy can be transferred from one form to another, the movement of energy from one location to another is known as energy transfer. We notice various energy transformations happening around us.

Following are the four ways through which energy can be transferred:

- **Mechanically – By the action of force**
- **Electrically – Electrically**
- **By Radiation – By Light waves or Sound waves**
- **By Heating – By conduction, convection, or radiation**

The process which results in the energy changing from one form to another is known as **energy transformation**.

While energy can be transformed or transferred, the total amount of energy does not change – this is called **energy conservation.**

S. No.	Equipment	Energy Transformed
1	Dynamo	Mechanical energy into electrical energy
2	Candle	Chemical energy into light and heat energy
3	Microphone	Sound energy into electrical energy
4	Loud speaker	Electrical energy into sound energy
5	Solar cell	Solar energy into electrical energy
6	Tube light	Electrical energy into light energy

7	Electric bulb	Electrical energy into light and heat energy
8	Battery	Chemical energy into electrical energy
9	Electric motor	Electrical energy into mechanical energy
10	Sitar	Mechanical energy into sound energy
11	Photo cell	Light energy into electric energy

3.HEAT AND THERMODYNAMICS

Heat is the energy that is transferred from one body to another due to differences in temperature. **The SI unit of heat is Joule.**

Temperature is a physical quantity that expresses the coldness and hotness of a body. **The SI unit of temperature is Kelvin.**

Methods of heat transfer

- **Conduction:** Conduction is the transfer of heat from the hotter part of the body to the colder part of the body without the actual movement of the particles in between.

- **Convection:** The transmission of heat due to the actual movement of the medium is called convection.

- **Radiation:** Radiation is the process by which the heat gets transmitted from one point to another without the action of any material in between.

Thermodynamics

- Heat is a form of energy that produces the sensation of hotness.

- Thermodynamics is the branch of physics that deals with the energy relationships involving heat, mechanical energy and other forms of energy. The entire formulation of thermodynamics is based on a few fundamental laws which have been established on the basis of the human experience of the experimental behavior of macroscopic aggregates of matter collected over a long period of time.

- Like solids and liquids, the gases also expand on heating.

- The volume of expansion of the gas depends not only on the temperature but also on the pressure to which it is subjected. Thus, there are three variables for gases: volume, pressure and temperature.

- To study the variation of any two variables, the third is kept constant. The interrelationships between these variables are known as the gas laws.

Kinetic Theory of Gases

We know that matter is composed of very large number of atoms and molecules.

Each of these molecules shows the characteristic properties of the substance of which it is a part.

Kinetic theory of gases attempts to relate the macroscopic or bulk properties such as pressure, volume and temperature of an ideal gas with its microscopic properties such as speed and mass of its individual molecules.

The kinetic theory is based on certain assumptions. (A gas whose molecules can be treated as point masses and there is no intermolecular force between them is said to be ideal.)

A gas at room temperature and atmospheric pressure (low pressure) behaves like an ideal gas.

Assumptions of Kinetic Theory of Gases

Clark Maxwell in 1860 showed that the observed properties of a gas can be explained on the basis of certain assumptions about the nature of molecules, their motion and interaction between them. Postulates of Kinetic Theory of Gases are as follows:

1. A gas consists of a very large number of identical rigid molecules, which move with all possible velocities randomly. The intermolecular forces between them are negligible.

2. Gas molecules collide with each other and with the walls of the container. These collisions are perfectly elastic.

3. Size of the molecules is negligible compared to the separation between them.

4. Between collisions, molecules move in straight lines with uniform velocities.

5. Time taken in a collision is negligible as compared to the time taken by a molecule between two successive collisions.

6. Distribution of molecules is uniform throughout the container.

Thermodynamic Terms

(i) Thermodynamic system

A thermodynamic system refers to a definite quantity of matter which is considered unique and separated from everything else, which can influence it. Every system is enclosed by an arbitrary surface, which is called its boundary. The boundary may enclose a solid, a liquid or a gas. It may be real or imaginary, either at rest or in motion and may change its size and shape. The region of space outside the boundary of a system constitutes its surroundings.

(a) Open System
It is a system which can exchange mass and energy with the surroundings. A water heater is an open system.

(b) Closed system
It is a system which can exchange energy but not mass with the surroundings. A gas enclosed in a cylinder fitted with a piston is a closed system.

(c) Isolated system
It is a system which can exchange neither mass nor energy with the surrounding. A filled thermos flank is an ideal example of an isolated system.

(ii) Thermodynamic Variables or Coordinates

To describe a thermodynamic system, we use its physical properties such on temperature (T), pressure (P), and volume (V). These are called thermodynamic variables.

Thermodynamic Equilibrium

A system that is in thermal, mechanical and chemical equilibrium is called the thermodynamic equilibrium.

- **Thermal equilibrium:** A thermodynamic system is said to be in thermal equilibrium if the temperature of every part of the system is the same as that of the surroundings.

- **Mechanical equilibrium:** A thermodynamic system is said to be in mechanical equilibrium if there is no unbalanced force on a part of the system or the whole system.

- **Chemical equilibrium:** A system is said to be in chemical equilibrium when its chemical composition is the same throughout the system.

Thermodynamic Process

- If any of the thermodynamic variables of a system change while going from one equilibrium state to another, the system is said to execute a thermodynamic process.

- For example, the expansion of a gas in a cylinder at constant pressure due to heating is a thermodynamic process.

- A graphical representation of a thermodynamic process is called a path.

Different types of thermodynamic processes.

(i) Reversible process

If a process is executed so that all intermediate stages between the initial and final states are equilibrium states and the process can be executed back along the same equilibrium states from its final state to its initial state, it is called reversible process. A reversible process is executed very slowly and in a controlled manner.

Consider the following **examples**:

1. Take a piece of ice in a beaker and heat it. You will see that it changes to water.
If you remove the same quantity of heat of water by keeping it inside a refrigerator, it again changes to ice (initial state).

2. Consider a spring supported at one end. Put some masses at its free end one by one. You will note that the spring elongates (increases in length). Now remove the masses one by one. You will see that spring retraces its initial positions.Hence it is a reversible process.
As such, a reversible process can only be idealised and never achieved in practice.

(ii) Irreversible process

A process which cannot be retraced along the same equilibrium state from final to the initial state is called irreversible process.

All natural processes are irreversible.

For example, heat produced during friction, sugar dissolved in water, or rusting of iron in the air. It means that for irreversible process, the intermediate states are not equilibrium states and hence such process cannot be represented by a path.

(iii) Isothermal process

A thermodynamic process that occurs at constant temperature is an isothermal process.

The expansion and compression of a perfect gas in a cylinder made of perfectly conducting walls are isothermal processes.

The change in pressure or volume is carried out very slowly so that any heat developed is transferred into the surroundings and the temperature of the system remains constant. The thermal equilibrium is always maintained.

(iv) Adiabatic process

A thermodynamic process in which no exchange of thermal energy occurs is an adiabatic process.

For example, the expansion and compression of a perfect gas in a cylinder made of perfect insulating walls.

(v) Isobaric process: A thermodynamic process that occurs at constant pressure is an isobaric process. Heating of water under atmospheric pressure is an isobaric process.

(vi) Isochoric process: A thermodynamic process that occurs at constant volume is an isochoric process. For example, heating of a gas in a vessel of constant volume is an isochoric process. In this process, volume of the gas remains constant so that no work is done.

In a **Cyclic Process** the system returns back to its initial state. It means that there is no change in the internal energy of the system

Zeroth Law of Thermodynamics

If two bodies or systems A and B are separately in thermal equilibrium with a third body C, then A and B are in thermal equilibrium with each other.

Internal Energy

- Internal Energy is the sum total of the kinetic energy and potential energy of the atoms/molecules due to the internal factors. The energy possessed by the atoms or molecules by virtue of their motion is called kinetic energy.

- **Internal energy is denoted by the letter U.**

- **Internal energy of a system = Kinetic energy of molecules + Potential energy of molecules.**

There are two methods to change the internal energy of the system, i.e., Heat and Work

Heat is the energy transferred due to the temperature difference between the system and the surrounding area. On heating, the kinetic energy of the molecules increases and therefore the internal energy increases.

Work is the energy spent to overcome an external force. When the system does work against an external pressure it tends to reduce the internal energy and on the other hand, when the system contracts due to the external pressure it tends to increase the internal energy.

First Law of Thermodynamics

- The first law of thermodynamics is, in fact, the law of conservation of energy for a thermodynamic system.

- It states that change in internal energy of a system during a thermodynamic process is equal to the sum of the heat given to it and the work done on it.

Second Law of Thermodynamics.

- **The Kelvin-Planck's statement** is about the performance of heat engines. In a heat engine, the working substance extracts heat from the source (hot body), converts a part of it into work and rejects the rest of heat to the sink (environment). There is no engine which converts the whole heat into work, without rejecting some heat to the sink. These observations led Kelvin and Planck to state the second law of thermodynamics as:

It is impossible for any system to absorb heat from a reservoir at a fixed temperature and convert whole of it into work.

- **Clausius statement of second law of thermodynamics** is based on the performance of a refrigerator. A refrigerator is a heat engine working in the opposite direction. It transfers heat from a colder body to a hotter body when external work is done on it. Here concept of external work done on the system is important. To do this external work, supply of energy from some external source is a must. These observations led Clausius to state the second law of thermodynamics in the following form.

It is impossible for any process to have as its sole result to transfer heat from a colder body to a hotter body without any external work.

Thus, the second law of thermodynamics plays a unique role for practical devices like heat engine and refrigerator.

Specific Heat Capacity

The specific heat capacity of a substance can be defined as the amount of heat required to raise the temperature of the unit mass of the substance through 1^0C.

(a) Specific Heat Capacity at Constant Volume:
The specific heat capacity at constant volume is the amount of heat required to raise the temperature 1 g of the gas through 1^0C keeping the volume of the gas constant.

(b) Specific Heat Capacity at Constant Pressure:
The specific heat capacity at constant pressure is the heat required to increase the temperature of 1 g of substance through 1^0C keeping the pressure constant.

Latent Heat

Latent heat is the amount of heat required to change the state of the unit mass of the substance at constant pressure and temperature.

$L = \Delta Q/m$

Latent heat of fusion: It is the amount of heat required to change the state from solid to liquid.

Latent heat of vaporization: It is the heat required to change the state from liquid to gas.

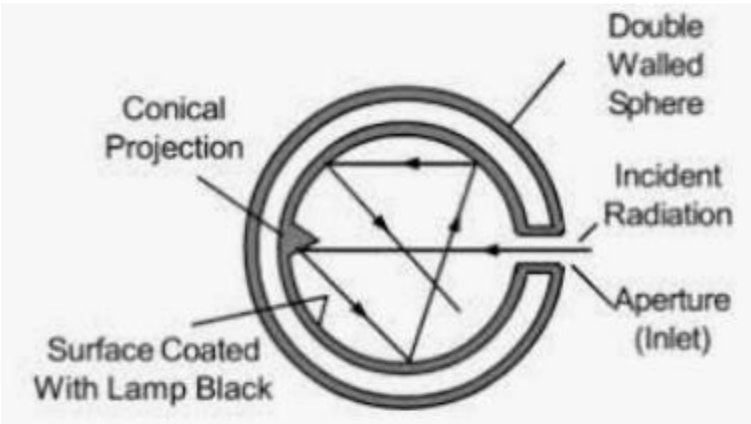
A **black body** is defined as the body which absorbs all the electromagnetic radiation(that is light) that strikes it irrespective of the angle of incidence and frequency of the radiation.

A black body can also be in thermal equilibrium in which it emits the electromagnetic black body radiation which is based on Planck’s law.

Example of Black Body

- A cavity with a hole in it is a good example of black body. When light is incident on the cavity, the light enters through the hole, but no light is reflected back from the cavity.
- A super-black material that absorbs 99.9% of light is a nickel-phosphorus alloy which is chemically prepared and is vertically aligned to the carbon nanotube arrays.

The radiation emitted by the black body is known as black body radiation.



4.OSCILLATIONS AND WAVES

Oscillation is defined as the process of repeating variations of any quantity or measure about its equilibrium value in time. Oscillation can also be defined as a periodic variation of a matter between two values or about its central value.

The term vibration is used to describe the mechanical oscillations of an object. However, oscillations also occur in dynamic systems or more accurately in every field of science. Even the beating of our heart creates oscillations. Meanwhile, objects that show motion around an equilibrium point are known as oscillators.

Examples of Oscillations:

- Most common examples for oscillation are the tides in the sea and the movement of a simple pendulum in a clock.

- Another example of oscillation is the movement of spring. The vibration of strings in guitar and other string instruments are also examples of oscillations.
- The pendulum moves back and forth and hence it creates an oscillating movement. Mechanical oscillations are called vibrations. A particle being vibrated means it oscillates between two points about its central point.
- Likewise, the movement of spring is also oscillation. The spring moves downward and then upward repeatedly and hence it produces an oscillating movement.
- A sine wave is a perfect example of oscillation. Here the wave moves between two points about a central value.
- The height or the maximum distance that the oscillation takes place is called the amplitude and the time taken to complete one complete cycle is called the time period of the oscillation.
- Frequency is the number of complete cycles that occur in a second. Frequency is the reciprocal of the time period.

  $F = 1 / T$

  where F is the frequency of oscillation

  and T is the time period of the oscillation.

<u>Periodic Motion</u>

You may have observed a clock and noticed that the pointed end of its seconds hand and that of its minutes hand move around in a circle, each with a fixed period. The seconds hand completes its journey around the dial in one minute but the minutes hand takes one hour to complete one round trip. However, a pendulum bob moves to and fro about a mean position and completes its motion from one end to the other.

A motion which repeats itself after a fixed interval of time is called **periodic motion**.
There are two types of periodic motion :(i) **non–oscillatory,** and (ii) **oscillatory**.
The motion of the hands of the clock is non-oscillatory but the to and fro motion of the pendulum bob is oscillatory. However, both the motions are periodic. It is important to note that an oscillatory motion is normally periodic but a periodic motion is not necessarily oscillatory. Remember that a motion which repeats itself in equal intervals of time is periodic and if it is about a mean position, it is **oscillatory**.

We know that earth completes its rotation about its own axis in 24 hours and days and nights are formed. It also revolves around the sun and completes its revolution in 365 days.
This motion produces a sequence of seasons. Similarly all the planets move around the Sun in elliptical orbits and each completes its revolution in a fixed interval of time. These are examples of periodic non-oscillatory motion.

A particle is said to execute simple harmonic motion if it moves to and fro about a fixed point periodically, under the action of a force F which is directly proportional to its displacement x from the fixed point and the direction of the force is opposite to that of the displacement.

Mathematically, we express it as

$F = -kx$
where k is constant of proportionality.

Basic Terms associated with SHM

1. **Displacement** is the distance of the harmonic oscillator from its mean (or equilibrium) position at a given instant.

2. **Amplitude** is the maximum displacement of the oscillator on either side of its mean position.

3. **Time period** is the time taken by the oscillator to complete one oscillation.

4. **Frequency** is the number of oscillations completed by an oscillator in one second. It is denoted by v. The SI unit of frequency is hertz (symbol Hz). Since v is the number of oscillations per second, the time taken to complete one oscillation is 1/v.

   Hence $T = 1/v$ or $v = (1/T)\ s^{-1}$.

5. **Phase** θ is the angle whose sine or cosine at a given instant indicates the position and direction of motion of the oscillator. It is expressed in radians.

6. **Angular Frequency (**ω) describes the rate of change of phase angle. It is expressed in radian per second.

Waves

A wave is a disturbance in a medium that carries energy without a net movement of particles.

Waves are of different types: Progressive and stationary, mechanical and electro-magnetic. These can also be classified as longitudinal and transverse depending on the direction of motion of the material particles with respect to the direction of propagation of wave in case of mechanical waves and electric and magnetic vectors in case of EM waves. Waves are so intimate to our existence.

Sound waves travelling through air make it possible for us to listen.
Light waves, which can travel even through vacuum make us see things and radio waves carrying different signals at the speed of light connect us to our dear ones through different forms of communication. In fact, wave phenomena is universal.

Essential properties of the medium for propagation of longitudinal and transverse waves are: the particles of the medium must possess and the medium must possess elasticity.

Longitudinal waves for propagation in a medium require volume elasticity but transverse waves need modulus of rigidity.

However, light waves and other electromagnetic waves, which are transverse, do not need any material medium for their propagation.

Types of Waves in Physics

Different types of waves have different sets of characteristics. Based on the orientation of particle motion and direction of energy, there are three categories:

- Mechanical waves
- Electromagnetic waves
- Matter waves

Mechanical Wave

- A mechanical wave is a wave that is an oscillation of matter and is responsible for the transfer of energy through a medium.
- The distance of the wave's propagation is limited by the medium of transmission. In this case, the oscillating material moves about a fixed point, and there is very little translational motion.

There are two types of mechanical waves:

- **Longitudinal waves –** In this type of wave, the movement of the particles is parallel to the motion of the energy, i.e. the displacement of the medium is in the same direction in which the wave is moving. Example – Sound Waves, Pressure Waves.
- **Transverse waves –** When the movement of the particles is at right angles or perpendicular to the motion of the energy, then this type of wave is known as a transverse wave. Light is an example of a transverse wave.

Electromagnetic Wave

- Electromagnetic waves are created by a fusion of electric and magnetic fields. The light you see, the colors around you are visible because of electromagnetic waves.
- One interesting property here is that unlike mechanical waves, electromagnetic waves do not need a medium to travel. All electromagnetic waves travel through a vacuum at the same speed, 299,792,458 ms^{-1}.

Following are the different types of electromagnetic waves:

- Microwaves
- X-ray
- Radio waves
- Ultraviolet waves

OPTICS

Light is a form of energy, which propagates as Electromagnetic waves whose nature is transverse. The speed of light in vacuum is $3x10^8$ m/s.

Like all the different types of light, the spectrum of visible light is absorbed and emitted in the form of tiny packets of energy called photons. These photons have both the properties of a wave as well as a particle.

Properties of light are as follows:

Reflection is one of the primary properties of light. Reflection is nothing but the images you see in the mirrors. Reflection is defined as the change in direction of light at an interface in-between two different media so that the wave-front returns into a medium from which it was originated. The typical examples for reflection of light include sound waves and water waves.

Laws of reflection at a plane surface:

Law 1 –The incident ray, the reflected ray and the normal to the reflecting surface at the point of incidence always lie in the same plane.
Law 2 –The angle of incidence is equal to the angle of reflection.

Speed of light

The rate at which the light travels in free space is called the Speed of light. For example, the light travels 30% slower in the water when compared to vacuum.

Refraction: The bending of light when it passes from one medium to another is called Refraction. This property of refraction is used in a number of devices like microscopes, magnifying lenses, corrective lenses, and so on. In this property, when the light is transmitted through a medium, polarization of electrons takes place which in turn reduces the speed of light, thus changing the direction of light.

Total Internal Reflection (TIR): When a beam of light strikes the water, a part of the light is reflected, and some part of the light is refracted. This phenomenon is called as Total internal reflection.

Dispersion: It is a property of light, where the white light splits into its constituent colours. Dispersion can be observed in the form of a prism.

Applications of Optics

The properties of optics are applied in various fields of Physics-

- The refraction phenomenon is applied in the case of lenses (Convex and concave) for the purpose of forming an image of the object.
- Geometrical optics is used in studies of how the images form in an optical system.
- In medical applications, it is used in the optical diagnosis of the mysteries of the human body.

Interference of Light

The effect of non-uniform energy distribution in the medium as a result of two light waves being superimposed is called interference.

Coherent and Incoherent Sources

Coherent Source: Two sources that emit a monochromatic light continuously with a zero (or) constant phase difference between them are called coherent sources.

Incoherent Source: The sources which do not emit light with constant phase difference are called incoherent sources.

Diffraction is a phenomenon in which a wave passes through a slit or obstacles. It is known as the bending of waves around an obstacle's end or through an aperture into the geometrical shadow of the obstacle.

Polarisation

Polarized waves are light waves in which the vibrations occur in a single plane. Plane polarized light consists of waves in which the direction of vibration is the same for all waves. In the image above, you can see that a Plane polarized light vibrates on only one plane. The process of transforming unpolarized light into the polarized light is known as **polarization**.

Following are the three types of polarization depending on the transverse and longitudinal wave motion:

- Linear polarization
- Circular polarization
- Elliptical polarization

Linear Polarization

In linear polarization, the electric field of light is limited to a single plane along the direction of propagation.

Circular Polarization

There are two linear components in the electric field of light that are perpendicular to each other such that their amplitudes are equal, but the phase difference is different.

Elliptical Polarization

The electric field of light follows an elliptical propagation. The amplitude and phase difference between the two linear components are not equal.

There are a few methods used in the polarization of light:

- Polarization by Transmission
- Polarization by Reflection
- Polarization by Scattering
- Polarization by Refraction

Following are the applications of polarization:

- Polarization is used in sunglasses to reduce the glare.
- Polaroid filters are used in plastic industries for performing stress analysis tests.
- Three-dimensional movies are produced and shown with the help of polarization.
- Polarization is used for differentiating between transverse and longitudinal waves.
- Infrared spectroscopy uses polarization.
- It is used in seismology to study earthquakes.

5.ELECTRICITY AND MAGNETISM

The branch of physics which deals with electrical charges at rest, it is called **electrostatics**.

Like charges repel and unlike charges attract each other.

There are only two kinds of charges in nature; positive and negative.

- Charge is conserved.
- Charge is quantised.

Coulomb's Law

We know that two stationary charges either attract or repel each other. The force of attraction or repulsion between them depends on their nature. Coulomb studied the nature of this force and in 1785 established a fundamental law governing it. From experimental observations, he showed that the electrical force between two static point charges $q1$ and $q2$ placed some distance apart is

– directly proportional to their product
– inversely proportional to the square of the distance r between them
– directed along the line joining the two charged particles and
– repulsive for same kind of charges and attractive for opposite charges.

Electric Field

The electric field **E** at a point is defined as the electric force **F** experienced by a positive test charge $q0$ placed at that point divided by the magnitude of the test charge. Mathematically, we write

$\mathbf{E} = F/\mathbf{q0}$

The following properties of the electric field lines:

1. The field lines start from a positive charge radially outward in all directions and terminate at infinity.

2. The field lines start from infinity and terminate radially on a negative charge.

3. For a dipole, field lines start from the positive charge and terminate on the negative charge.

4. A tangent at any point on field line gives the direction of electric field at that point.

5. The number of field lines passing through unit area of a surface drawn perpendicular to the field lines is proportional to the field strength on this surface.

6. Two field lines never cross each other.

Electric Potential

The **electric potentia**l at any point in an electric field is equal to the work done against the electric force in moving a unit positive charge from outside the electric field to that point. Electric potential is a scalar quantity, as it is related to work done.

The SI unit of potential and potential difference is **volt.**

1 **volt** = 1 **joule**/1 **coulomb**

Applications of Electrostatics:

Electrostatics provides basis for the theory of Electromagnetics, apart from useful assistance in many fields of Science and Technology.

- Capacitors are essential parts of most electronic and electrical circuitry. These play a very crucial role in power transmission.
- Gold leaf electroscope – the simple device used for detecting charge, paved the way for cosmic ray research.
- Lightning conductor devised by Benjamin Franklin is still used to protect sky-scrappers from the strokes of lightning and thunder.
- The working of photocopiers, so common these days, is based on the principle of electrostatics.

What is Magnetism?

Magnetism is a concept introduced in Physics to help you understand one of the fundamental interactions in nature, the interaction between moving charges. Like the gravitational force and the electrostatic force, the magnetic force is an interaction at a distance.

MAGNETS AND THEIR PROPERTIES

The phenomenon of magnetism was known to Greeks as early as 600 B.C. They observed that some stones called magnetite attracted iron pieces. The pieces of naturally occurring magnetite are called **natural magnets**. Natural magnets are weak, but materials like iron, nickel, cobalt may be converted into strong permanent magnets. All magnets–natural or artificial – have same properties.

(i) Directive Property**:** A small bar magnet, when suspended freely on its centre of mass so as to rotate about a vertical axis, it always stays in approximately geographical north-south direction.

(ii) Attractive Property**:** A magnet attracts small pieces of magnetic materials like iron, nickel and cobalt. The force of attraction is maximum at points near the ends of the magnet. These points are called **poles** of the magnet.
Ina freely suspended magnet, the pole which points towards the geographical north is called is **North pole** and the one which points towards the geographical south is called **South pole**.

(iii) Unlike poles of two magnets attract each other and like poles repel.

(iv) The poles of a magnet are inseparable, i.e., the simplest specimen providing magnetic field is a magnetic dipole.

(v) When a magnet is brought close to a piece of iron, the nearer end of the piece of iron acquires opposite polarity and the farther end acquires same polarity. This phenomenon is called **magnetic induction**.

A steady current in a wire produces a steady magnetic field. Faraday initially (and mistakenly) thought that a steady magnetic field could produce electric current. Some of his investigations, an induced current is also observed to flow through the coil, if this is moved relative to the magnet. The presence of such currents in a circuit implies the existence of an **induced electromotive force (emf)** across the free ends of the coil.

This phenomenon in which a magnetic field induces an emf is termed as **electromagnetic induction**. Faraday's genius recognised the significance of this work and followed it up. The quantitative description of this phenomenon is known as Faraday's law of electromagnetic induction.

Faraday's law states that an emf is induced across a loop of wire when the magnetic flux linked with the surface bound by the loop changes with time. The magnitude of induced emf is proportional to the rate of change of magnetic flux.

Inductance

When current in a circuit changes, a changing magnetic field is produced around it. If a part of this field passes through the circuit itself, current is induced in it. Now suppose that another circuit is brought in the neighbourhood of this circuit. Then the magnetic field through that circuit also changes, inducing an emf across it. Thus, induced emfs can appear in these circuits in two ways:

- By changing current in a coil, the magnetic flux linked with each turn of the coil changes and hence an induced emf appears across that coil. This property is called **self-induction**.

- For a pair of coils situated close to each other such that the flux associated with one coil is linked through the other, a changing current in one coil induces an emf in the other. In this case, it is known as **mutual induction** of the pair of coils.

Difference between Electricity and Magnetism

There are numerous ways by which we can differentiate between magnetism and electricity. Some main electricity and magnetism differences are given in the points mentioned below.

- The major difference between electricity and magnetism is the presence of magnetism.
- Electricity can be present in a static charge, while magnetism's presence is only felt when there are moving charges as a result of electricity.
- In simple words, electricity can exist without magnetism, but magnetism cannot exist without electricity.

6.MODERN PHYSICS

Atoms are defined as ***"the basic building blocks of matter"***.

It is the smallest constituent unit of matter that possess the properties of the chemical element. Atoms don't exist independently, instead, they form ions and molecules which further combine in large numbers to form matter that we see, feel and touch.

An atom is composed of three particles, namely, **neutrons, protons and electrons** with hydrogen as an exception without neutrons.

- Every atom has a nucleus that bounds one or more electrons around it.
- The nucleus has typically a similar number of protons and neutrons which are together known as nucleons.
- The protons are positively charged, electrons are negatively charged and neutrons are neutral.

What is Radioactivity?

Due to nuclear instability, an atom's nucleus exhibits the phenomenon of Radioactivity. Energy is lost due to radiation that is emitted out of the unstable nucleus of an atom. Two forces, namely the force of repulsion that is electrostatic and the powerful forces of attraction of the nucleus keep the nucleus together. These two forces are considered extremely strong in the natural environment. The chance of encountering instability increases as the size of the nucleus increases because the mass of the nucleus becomes a lot when concentrated. That's the reason why atoms of Plutonium, Uranium are extremely unstable and undergo the phenomenon of radioactivity.

Henry Becquerel discovered radioactivity by accident. A Uranium compound was placed in a drawer containing photographic plates, wrapped in a black paper. When the plates were examined later it was found that they were exposed! This exposure gave rise to the concept of Radioactive decay. Radioactivity can be seen in such forms

- Gamma Decay (Photons having high energy are emitted)
- Beta Decay (Emission consists of Electrons)
- Alpha Decay (Emission consists of Helium nucleus)

Laws of Radioactivity

- Radioactivity is the result of the decay of the nucleus.
- The rate of decay of the nucleus is independent of temperature and pressure.
- Radioactivity is dependent on the law of conservation of charge.
- The physical and chemical properties of the daughter nucleus are different from the mother nucleus.
- The emission of energy from radioactivity is always accompanied by alpha, beta, and gamma particles.
- The rate of decay of radioactive substances is dependent on the number of atoms that are present at the time.

Units of Radioactivity

Curie and Rutherford are the units of radioactivity.

$1C = 3.7 \times 10^4$ Rd is the relationship between Curie and Rutherford.

Advantages of radioactivity are:

- Gamma rays are used to kill cancerous cells and hence used in radiotherapy.
- Cobalt-60 is used to destroy carcinogenic cells.
- Gamma rays are used in scanning the internal parts of the body.
- Gamma rays kill microbes present in food and prevent it from decay by increasing the shelf life.
- Age of the rocks can be studied using radioactive radiations by measuring the argon content present in the rock.

Disadvantages of radioactivity are:

- High dosage of radioactive radiation on the body might lead to death.

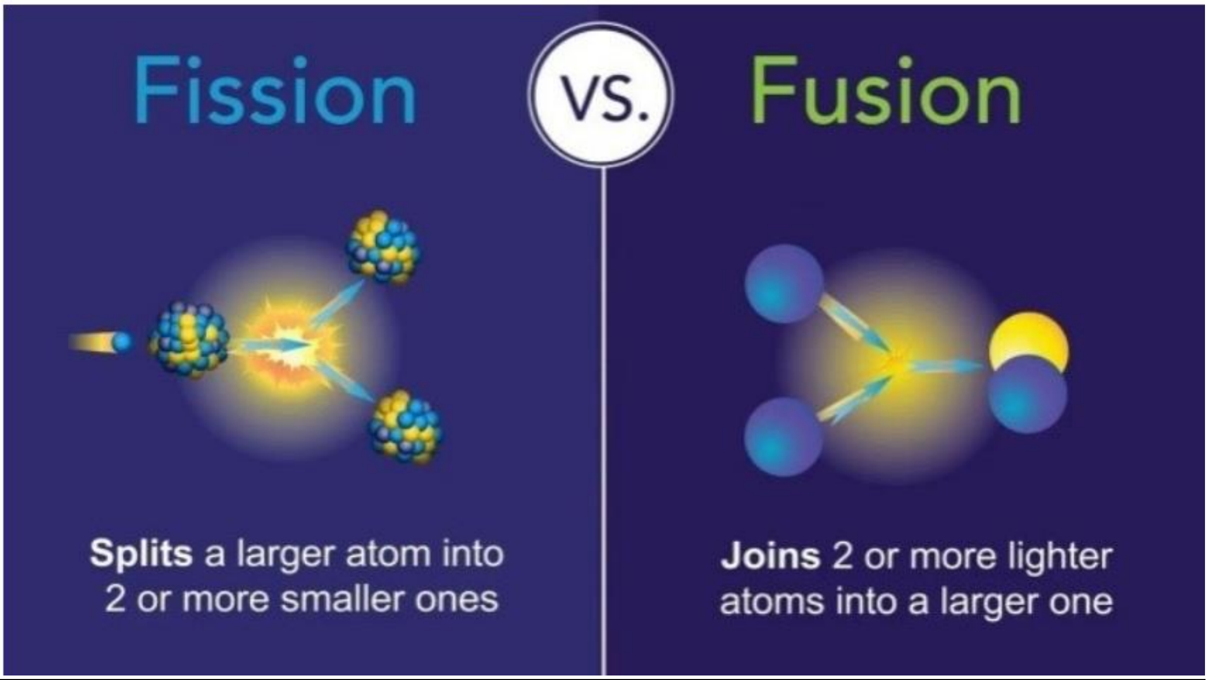
- Radioactive isotopes are expensive.

Nuclear reactions are processes in which one or more nuclides are produced from the collisions between two atomic nuclei or one atomic nucleus and a subatomic particle. The nuclides produced from nuclear reactions are different from the reacting nuclei (commonly referred to as the parent nuclei).

Two notable types of nuclear reactions are **nuclear fission reactions** and **nuclear fusion reactions**. The former involves the absorption of neutrons (or other relatively light particles) by a heavy nucleus, which causes it to split into two (or more) lighter nuclei. Nuclear fusion reactions are the processes in which two relatively light nuclei combine (via a collision) to afford a single, heavier nucleus.

Nuclear fission refers to the splitting of an atomic nucleus into two or lighter nuclei. This process can occur through a nuclear reaction or through radioactive decay. Nuclear fission reactions often release a large amount of energy, which is accompanied by the emission of neutrons and gamma rays (photons holding huge amounts of energy, enough to knock electrons out of atoms).

In nuclear fusion reactions, at least two atomic nuclei combine into a single nucleus. Subatomic particles such as neutrons or protons are also formed as products in these nuclear reactions.



7.ELECTRONICS

Electronics also mainly deals with any electronic components present in an electronic system. Some of the most widely used applications of electronics are cathode ray tubes, audio equipment, guitar amplifiers and microwaves.

In simple terms, an electrical conductor is defined as materials that allow electricity to flow through them easily. This property of conductors that allow them to conduct electricity is known as conductivity.

The flow of electrons in a conductor is known as the electric current and the force required to make that current flow through the conductor is known as voltage.

When a charge is transferred to such an element, it gets distributed across the entire surface of the object, which results in the movement of electrons in the object. The charges transferred to an electrical conductor distribute until the force of repulsion between electrons in areas of excess electrons is decreased to the minimum value. When such an object is brought in contact with another conductor, the charge gets transferred from the first conductor to the other until the overall repulsion due to charge is minimized.

Examples of conductors: Copper, Gold, Iron etc.

Insulators are materials that hinder the free flow of electrons from one particle of the element to another. If we transfer some amount of charge to such an element at any point, the charge remains at the initial location and does not get distributed across the surface. The most common process of charging of such elements is charging by rubbing (for some elements, with the help of suitable materials).

Examples of insulators: Plastic, Wood, Glass etc

What are Semiconductors?

Semiconductors are the materials which have **conductivity** between **conductors** and **insulators**. Semiconductors can be compounds such as gallium arsenide or pure elements, such as germanium or silicon.

Examples of Semiconductors:

Gallium arsenide, germanium, and silicon are some of the most **commonly used semiconductors**. Silicon is used in electronic circuit fabrication and gallium arsenide is used in solar cells, laser diodes, etc.

Holes and Electrons in Semiconductors

Holes and electrons are the types of charge carriers accountable for the flow of current in semiconductors. **Holes** (valence electrons) are the positively charged electric charge carrier whereas **electrons** are the negatively charged particles. Both electrons and holes are equal in magnitude but opposite in polarity.

Conduction Band and Valence Band in Semiconductors

Valence Band:

The energy band involving the energy levels of valence electrons is known as the valence band. It is the highest occupied energy band. When compared with insulators, the band gap in semiconductors is smaller. It allows the electrons in the valence band to jump into the conduction band on receiving any external energy.

Conduction Band:

It is the lowest unoccupied band that includes the energy levels of positive (holes) or negative (free electrons) charge carriers. It has conducting electrons resulting in the flow of current. The conduction band possess high energy level and are generally empty. The conduction band in semiconductors accepts the electrons from the valence band.

What is Fermi Level in Semiconductors?

Fermi level (denoted by EF) is present between the valence and conduction bands. It is the highest occupied molecular orbital at absolute zero. The charge carriers in this state have their own quantum states and generally do not interact with each other. When the temperature rises above absolute zero, these charge carriers will begin to occupy states above Fermi level.

Semiconductors can conduct electricity under preferable conditions or circumstances. This unique property makes it an excellent material to conduct electricity in a controlled manner as required.

Unlike conductors, the charge carriers in semiconductors arise only because of external energy (thermal agitation). It causes a certain number of valence electrons to cross the energy gap and jump into the conduction band, leaving an equal amount of unoccupied energy states, i.e. holes. Conduction due to electrons and holes are equally important.

Some Important Properties of Semiconductors are:

1. Semiconductor acts like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
2. Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches, and amplifiers.
3. Lesser power losses.
4. Semiconductors are smaller in size and possess less weight.
5. Their resistivity is higher than conductors but lesser than insulators.
6. The resistance of semiconductor materials decreases with the increase in temperature and vice-versa.

Semiconductors can be classified as:

- **Intrinsic Semiconductor**
- **Extrinsic Semiconductor**

Intrinsic Semiconductor

An **intrinsic type of semiconductor material** is made to be very pure chemically. It is made up of only a single type of element.

Extrinsic Semiconductor

The conductivity of semiconductors can be greatly improved by introducing a small number of suitable replacement atoms called IMPURITIES. The process of adding impurity atoms to the pure semiconductor is called DOPING. Usually, only 1 atom in 10^7 is replaced by a dopant atom in the doped semiconductor. An extrinsic semiconductor can be further classified into:

- **N-type Semiconductor**
- **P-type Semiconductor**

Applications of Semiconductors

Semiconductors are used in almost all electronic devices.

Their reliability, compactness, low cost and controlled conduction of electricity make them ideal to be used for various purposes in a wide range of components and devices.

Transistors, diodes, photo sensors, microcontrollers, integrated chips and much more are made up of semiconductors.

Uses of Semiconductors in Everyday life

- Temperature sensors are made with semiconductor devices.
- They are used in 3D printing machines.
- Used in microchips and self-driving cars.
- Used in calculators, solar plates, computers and other electronic devices.
- Transistor and MOSFET used as a switch in Electrical Circuits are manufactured using the semiconductors.

Industrial Uses of Semiconductors

The physical and chemical properties of semiconductors make them capable of designing technological wonders like microchips, transistors, LEDs, solar cells, etc.

The microprocessor used for controlling the operation of space vehicles, trains, robots, etc is made up of transistors and other controlling devices which are manufactured by semiconductor materials.

Logic gates are an important concept if you are studying electronics. These are important digital devices that are mainly based on the Boolean function. Logic gates are used to carry out logical operations on single or multiple binary inputs and give one binary output. In simple terms, logic gates are the electronic circuits in a digital system.

There are several basic logic gates used in performing operations in digital systems. The common ones are;

- OR Gate
- AND Gate
- NOT Gate

Application of Logic Gates

Logic gates have a lot of applications but they are mainly based upon their mode of operations or their truth table. Basic logic gates are often found in circuits such as safety thermostat, push-button lock, automatic watering system, light-activated burglar alarm and many other electronic devices.

One of the primary benefits is that basic logic gates can be used in a mixture of different combinations if the operations are advanced. Besides, there is no limit to the number of gates that can be used in a single device. However, it can be restricted due to the given physical space in the device. In digital integrated circuits (ICs) we will find an array of the logic gate area unit.

Communication is a process that involves sending and receiving of messages through a verbal and non-verbal method. The sender sends a message, the receiver receives a message and sends it back with the feedback to the sender again.

Communication Process

The communication is a process that starts with the development of thoughts by a sender who conveys the message using a various channel to the receiver, who then sends him a message as feedback. There are seven main components of the communication process:

- **Sender –** Here, the sender conceptualizes the idea or the conversation he wants to convey it to the recipient.
- **Encoding –** Now the sender starts the encoding process where he utilizes words or non-verbal means to translate the thought into a message.
- **Message –** After encoding, the sender receives the message that he wants to send.
- **Communication Channel –** The sender then decides through which medium or channel he/she wants to send the message to the recipient. They must choose the channel to have an effective and correct interpretation of a message to the recipient.
- **Receiver –** The receiver receives the message and tries to comprehend in the best possible way.
- **Decoding –** In this step, the receiver translates the sender's information and tries to perceive it most suitably.
- **Feedback –** It is the last step of the communication process that assures the recipient, has received the information and understood correctly as the sender designed it.

List of Important Terms and their definitions

1	Acceleration	The rate of change of velocity of an object with respect to time
2	Angular Momentum	A measure of the momentum of a body in rotational motion about its centre of mass
3	Alloy	The mixture of metal with other metal or other elements.
4	Ammeter	An instrument that is used to measure current.
5	Amorphous solid	It is a type solid which do not have definite geometrical shape. Or it is non-crystalline solid.
6	Ampere	A unit that describes the rate of flow of electricity (current).
7	Amplifier	It is an electronic device that can increase the power of a signal (a time-varying voltage or current).
8	Amplitude	Height of a wave measured from its centre(normal) position.
9	Alpha particle	Consist of two protons and two neutrons bound together into a particle identical to a helium nucleus.
11	Astrophysics	The branch of astronomy that deals with the physics of the universe.
12	Atom	A basic unit of matter that consists of a dense central nucleus surrounded by a cloud of negatively charged electrons.
13	Atomic mass unit	one-twelfth the mass of an atom of the isotope 12⁄6C
14	Avogadro's Number	The number of molecules in exactly 12g of carbon-12, equal to 6.022×10^{23}.
15	Battery	Battery is combination of two or more cells (electric), which produces electricity.
16	Beam	A structural element that is capable of withstanding load primarily by resisting bending.
17	Beta particle	High-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei.
18	Biophysics	An interdisciplinary science using methods of, and theories from, physics to study biological systems.
19	Black hole	A region of space-time where gravity prevents anything, including light, from escaping.
20	Coulomb	The SI derived unit of electric charge. It is defined as the charge transported by a steady current of one ampere in one second.

21	Collision	A collision in physics occurs when any two objects bump into each other.
22	Classical mechanics	A sub-field of mechanics that is concerned with the set of physical laws describing the motion of bodies under the action of a system of forces.
23	Celsius scale	A scale and unit of measurement for temperature, also known as Centigrade.
24	Centre of gravity	The point in a body around which the resultant torque due to gravity forces vanish. Near the surface of the earth, where the gravity acts downward as a parallel force field, the centre of gravity and the centre of mass are the same.
25	Centre of mass	A distribution of mass in space is the unique point where the weighted relative position of the distributed mass sums to zero.
26	Convection	The transfer of heat by the actual transfer of matter
27	Cyclotron	A type of particle accelerator in which charged particles accelerate outwards from the centre along a spiral path
28	Density	The mass density or density of a material is its mass per unit volume.
29	Distance	A numerical description of how far apart objects are.
30	Displacement	In physics, displacement refers to an object's overall change in position. It is a vector quantity.
31	Elasticity	A physical property of materials which return to their original shape after they are deformed.
32	Electric charge	A physical property of matter that causes it to experience a force when near other electrically charged matter. There exist two types of electric charges, called positive and negative.
33	Electric circuit	An electrical network consisting of a closed loop, giving a return path for the current.
34	Electric current	A flow of electric charge through a conductive medium.
35	Electric field	The region of space surrounding electrically charged particles and time-varying magnetic fields.
36	Electric power	The rate at which electric energy is transferred by an electric circuit.
37	Electronics	A field that deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits, and associated passive interconnection technologies.
38	Energy	Energy is the ability to do work. The standard unit of measure for energy is the joule.
39	Entropy	a quantity which describes the randomness of a substance or system

40	First law of motion	The first law of motion states that any object in motion will continue to move in the same direction and speed unless external forces act on it.
41	Force	Force is the measurement of a push or pull on an object. Force is a vector measured in Newton.
42	Friction	Friction is the resistance of motion when one object rubs against another. It is a force and is measured in Newton.
43	Fusion	A nuclear reaction in which two or more atomic nuclei join together, or "fuse", to form a single heavier nucleus.
44	Gravity	Gravity is a force caused when the mass of physical bodies attract each other. On Earth gravity pulls at objects with an acceleration of 9.8 m/s^2.
45	Gamma ray	Electromagnetic radiation of high frequency and therefore high energy.
46	Impulse	An impulse is a change in momentum.
47	Heat	Energy transferred from one body to another by thermal interaction.
48	Ion	An atom or molecule in which the total number of electrons is not equal to the total number of protons, giving the atom a net positive or negative electrical charge.
49	Ionic bond	A type of chemical bond formed through an electrostatic attraction between two oppositely charged ions.
50	Ionization	The process of converting an atom or molecule into an ion by adding or removing charged particles such as electrons or ions.
51	Isotope	Variants of a particular chemical element. While all isotopes of a given element share the same number of protons, each isotope differs from the others in its number of neutrons.
52	Joule	The joule is the standard unit of measure for energy and work.
53	Kelvin	A unit of measurement for temperature. The Kelvin scale is an absolute, thermodynamic temperature scale using as its null point absolute zero.
54	Kinetic energy	Kinetic energy is the energy an object has due to its motion. It is a scalar quantity.
55	Light	Visible light is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of sight.
56	Magnetic field	A mathematical description of the magnetic influence of electric currents and magnetic materials. The magnetic field at any given point is specified by both a direction and a magnitude (or strength); as such it is a vector field.
57	Magnetism	A property of materials that respond to an applied magnetic field.
58	Mass balance	An application of conservation of mass to the analysis of physical

		systems, also called 'material balance'.
59	Mass density	A materials mass per unit volume, also just called density.
60	Molar mass	A physical property of matter. It is defined as the mass of a given substance divided by its amount of substance. The unit for molar mass is g/mol.
61	Molecule	An electrically neutral group of two or more atoms held together by covalent chemical bonds.
62	Momentum	Momentum is a measurement of mass in motion. Momentum is equal to the mass times the velocity of an object. It is a vector measured in Newton-seconds.
63	NanoTechnology	The manipulation of matter on an atomic and molecular scale.
64	Neutrino	An electrically neutral subatomic particle.
65	Nuclear physics	The field of physics that studies the constituents and interactions of atomic nuclei.
66	Newton	The Newton is the standard unit of measure for force.
67	Optics	The branch of physics which involves the behaviour and properties of light.
68	Ohm	The SI derived unit of electrical resistance.
69	Pascal	The Pascal is the standard unit of measure for pressure.
70	Photon	An elementary particle, the quantum of light and all other forms of electromagnetic radiation, and the force carrier for the electromagnetic force.
71	Potential energy	Potential energy is the energy stored by an object due to its state or position. It is measured in joules.
72	Physics	It is the general analysis of nature, conducted in order to understand how the universe behaves.
73	Power	Power is a measurement of the rate at which energy is used. The standard unit for power is the watt.
74	Power (electric)	The rate at which electric energy is transferred by an electric circuit.
75	Pressure	The ratio of force to the area over which that force is distributed.
76	Probability	A measure of the expectation that an event will occur or a statement is true.
77	Pressure	Pressure is the force over a given area. Pressure is measured in Pascal.
78	Quark	An elementary particle and a fundamental constituent of matter.
79	Quantum mechanics	A branch of physics dealing with physical phenomena at microscopic scales, where the action is on the order of the Planck constant.

80	Refraction	Refraction is the change in direction of wave propagation due to a change in its transmission medium.
81	Rotational energy	The kinetic energy due to the rotation of an object and forms part of its total kinetic energy.
82	Scalar	A scalar is a measurement that only measures the magnitude.
83	Speed	Speed is the measurement of how fast on object moves relative to a reference point. It is a scalar quantity measured by distance over time.
84	Science	A systematic enterprise that builds and organises knowledge in the form of testable explanations and predictions about the universe.
85	Sound	A mechanical wave that is an oscillation of pressure transmitted through a solid, liquid, or gas, composed of frequencies within the range of hearing.
86	Superconductor	A phenomenon of exactly zero electrical resistance and expulsion of magnetic fields occurring in certain materials when cooled below a characteristic critical temperature.
87	Temperature	A physical property of matter that quantitatively expresses the common notions of hot and cold.
88	Vector	A vector is a quantity that has both a magnitude and a direction.
89	Velocity	Velocity is the rate of displacement.
90	Wave	A disturbance or oscillation that travels through space -time, accompanied by a transfer of energy.
91	Wavelength	The wavelength of a sinusoidal wave is the spatial period of the wave.
92	Wind	The flow of gases on a large scale.
93	X Ray	A high energy photon.
94	Young’s modulus	A measure of the stiffness of a solid material which defines the relationship between stress and strain.
95	Zeeman effect	The effect of splitting a spectral line in the presence of a static magnetic field.