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OPEN AND DISTANCE LEARNING(ODL) PROGRAMMES
(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

III YEAR

B.Sc. Physics

Course Material

Modern Physics

Prepared
_By_

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MODERN PHYSICS

Unit –I: Waves and Vibrations

Waves – Generation of waves by vibrating particles – Types of wave motion, transverse, and longitudinal wave motion – Simple harmonic motion – Vibration of spring mass system.

Unit –II: Electrostatics

Coulomb's Law – Intensity of Electric Field – Intensity due to a point charge – Electric Flux – Electric Potential – Electric Potential due to a Point Charge

Unit –III: Electricity

Ohm's law – Resistance of a conductor – specific resistance – Heating effect of current and concept of electric power

Unit –IV: Semiconductor Physics

Energy bands – intrinsic and extrinsic semiconductor – p-n junction diode – characteristics of diode

Unit –V: Superconductivity

Phenomenon of superconductivity – Type I superconductor – Type II superconductor – applications of superconductor.

Books for References:

1. Modern Physics, R. Murugesan & Kiruthiga Sivaprasth, S.Chand & Co.
2. Concept of Physics, Prof. H.C. Verma, Part – 1 (Bharti Bhawan).
3. Concept of Physics, Prof. H. C. Verma, Part – 2 (Bharti Bhawan).

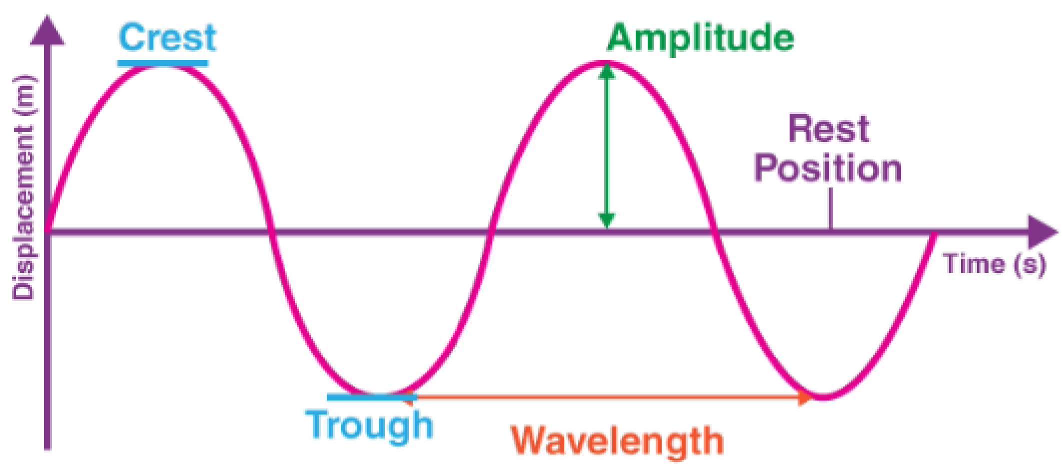
Unit –I: Waves and Vibrations

Waves – Generation of waves by vibrating particles – Types of wave motion, transverse, and longitudinal wave motion – Simple harmonic motion – Vibration of spring mass system.

Waves:

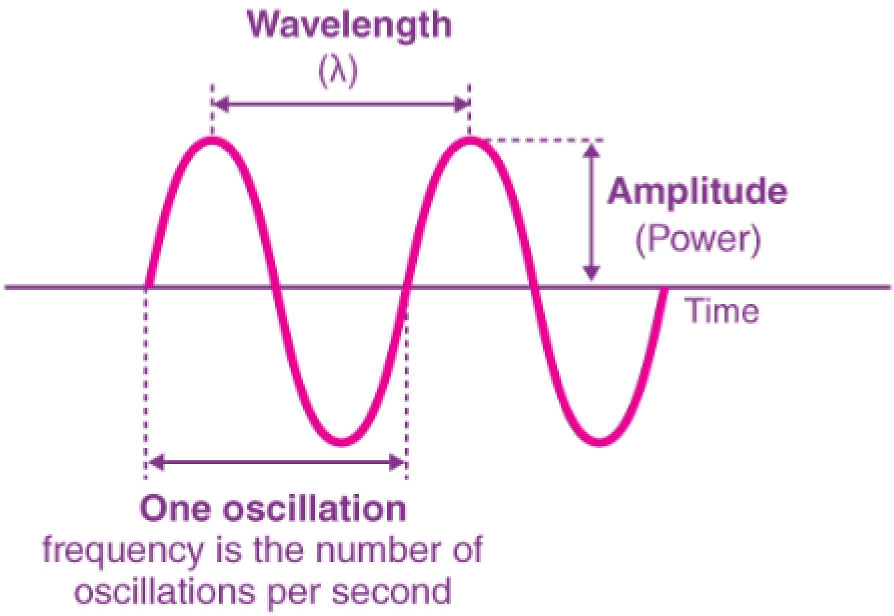
A wave is a disturbance in a medium that carries energy without a net movement of particles. It may take the form of elastic deformation, a variation of pressure, electric or magnetic intensity, electric potential, or temperature.

A wave is a flow or transfer of energy in the form of oscillation through a medium – space or mass. Sea waves or tides, a sound we hear, a photon of light travelling, and even the movement of small plants blown by the wind are all examples of different waves. A simple wave illustration is as follows.



Introduction of Waves

- Transfers energy.
- Usually involves a periodic, repetitive movement.
- Does not result in a net movement of the medium or particles in the medium (mechanical wave).



There are some basic descriptors of a wave. Wavelength is the distance between two successive identical parts of the wave. Amplitude is the maximum displacement from the neutral position. This represents the energy of the wave. Greater amplitude carries greater energy. Displacement is the position of a particular point in the medium as it moves as the wave passes. Maximum displacement is the amplitude of the wave

Frequency (f) is the number of repetitions per second in Hz, Period (T) is the time for one wavelength to pass a point.

The velocity (v) of the wave is the speed at which a specific part of the wave passes a point. The speed of a light wave is c.

Types of Waves:

The types of waves are given below.

Transverse Waves

Waves in which the medium moves at right angles to the direction of the wave.

Examples of transverse waves:

- Water waves (ripples of gravity waves, not sound through water)
- Light waves
- S-wave earthquake waves
- Stringed instruments
- Torsion wave

The high point of a transverse wave is a crest. The low part is a trough.

Longitudinal Wave:

A longitudinal wave has the movement of the particles in the medium in the same dimension as the direction of movement of the wave.

Examples of longitudinal waves:

- Sound waves
- P-type earthquake waves
- Compression wave

Parts of longitudinal waves:

Compression: where the particles are close together.

Rarefaction: where the particles are spread apart.

Mechanical waves:

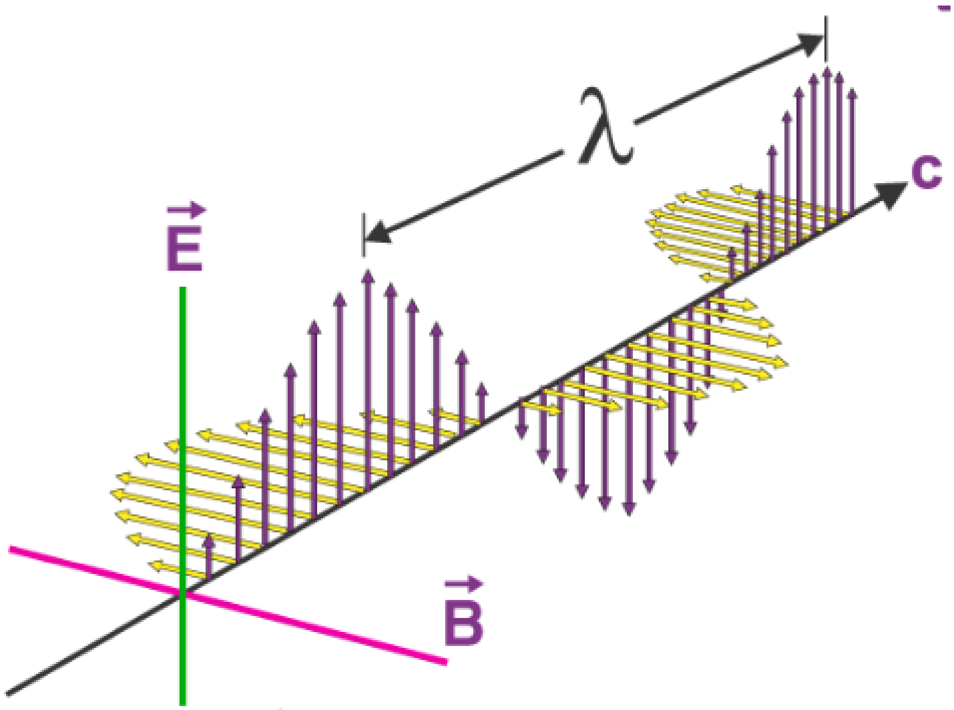
A wave which needs a medium in order to propagate itself. Sound waves, waves in a slinky, and water waves are all examples of this.

Matter Waves:

Any moving object can be described as a wave When a stone is dropped into a pond, the water is disturbed from its equilibrium positions as the wave passes; it returns to its equilibrium position after the wave has passed.

Electromagnetic Waves:

These waves are disturbance that does not need any object medium for propagation and can easily travel through the vacuum. They are produced due to various magnetic and electric fields. The periodic changes that take place in magnetic and electric fields and therefore known as electromagnetic waves.



Electromagnetic wave

Wave Speed Formula

It is the total distance covered by the wave in a given time period. The formula for wave speed is given as,

Wave Speed = Distance Covered/Time taken

Difference between Longitudinal and Transverse Waves:

Transverse Wave	Longitudinal Wave
The movement of the particle is perpendicular to the direction of the wave.	The movement of the particle is along the direction of the wave.
It consists of troughs and crests.	It contains refractions and compressions.
Travels only in solids.	It can travel through all states of matter.
Light waves are transverse waves.	Sound waves are longitudinal waves.
The particles are displaced perpendicular to the direction of the travelling wave.	The movement of particles is usually parallel to the movement of energy.

Properties of Waves

The prime properties of waves are as follows:

Amplitude – Wave is an energy transport phenomenon. Amplitude is the height of the wave, usually measured in metres. It is directly related to the amount of energy carried by a wave.

Wavelength – The distance between identical points in the adjacent cycles of crests of a wave is called a wavelength. It is also measured in metres.

Period – The period of a wave is the time for a particle on a medium to make one complete vibrational cycle. As the period is time, hence is measured in units of time such as seconds or minutes.

Frequency – Frequency of a wave is the number of waves passing a point in a certain time. The unit of frequency is hertz (Hz) which is equal to one wave per second.

The period is the reciprocal of the frequency and vice versa.

$$Period = \frac{1}{Frequency}$$

OR

$$Frequency = \frac{1}{Period}$$

Speed – The speed of an object means how fast an object moves and is usually expressed as the distance travelled per time of travel. The speed of a wave refers to the distance travelled by a given point on the wave (crest) in a given interval of time. That is –

$$Speed = \frac{Distance}{Time}$$

Speed of a wave is thus measured in metre/second i.e. m/s.

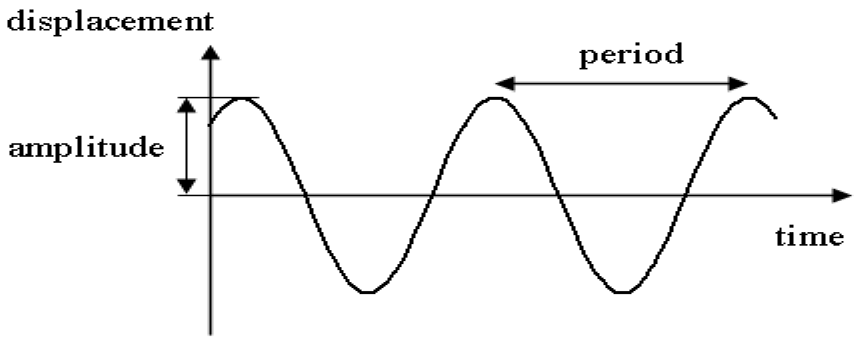
Simple Harmonic Motion

A motion is *simple harmonic* only when the restoring force (or acceleration) is directly proportional to displacement from the mean position and always directed toward it.

Examples of SHM

1. Oscillations of a mass attached to a spring
2. Small oscillations of a simple pendulum
3. Vibrations of tuning fork prongs

F= −kx or a= − ω2x



Simple harmonic wave propagation

where k is the force constant and ω is the angular frequency.

F=ma

$$m\frac{d^2x}{dt^2} = -Kx$$

$$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0$$

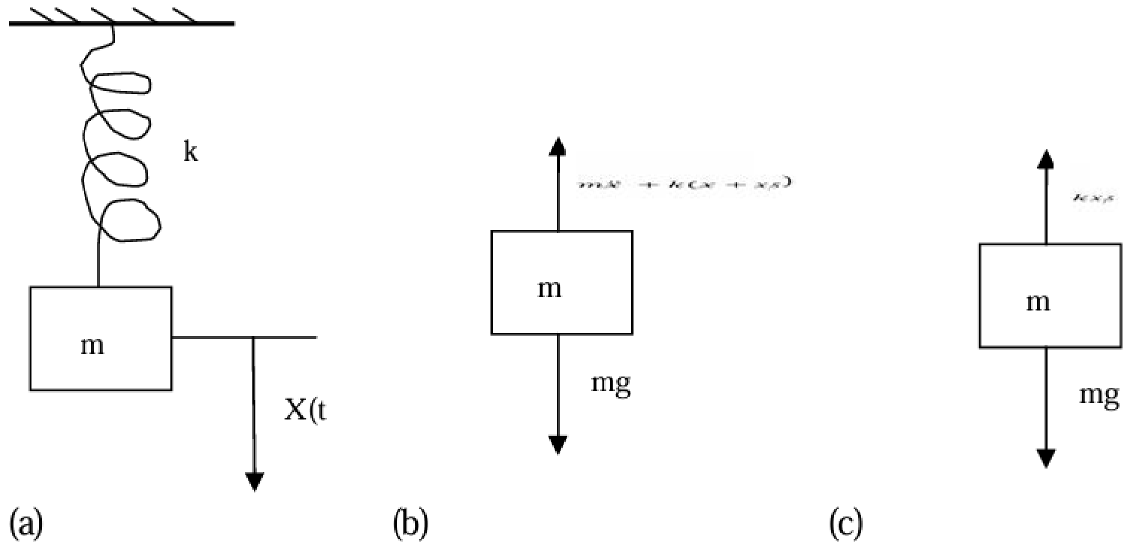
Let $\omega^2 = K/M$

Hence, the equation of motion is:

$$\frac{d^2x}{dt^2} + \omega^2\mathrm{x} = 0$$

Vibration of spring mass system

Most of the system exhibit simple harmonic motion or oscillation. These systems are said to have elastic restoring forces. Such systems can be modeled, in some situations, by a spring-mass schematic, as illustrated in Figure This constitutes the most basic vibration model of a machine structure and can be used successfully to describe a surprising number of devices, machines, and structures. This system provides a simple mathematical model that seems to be more sophisticated than the problem requires. This system is very useful to conceptualize the vibration problem in different machine components. The single degree of freedom system is indicating as



(a) Spring-mass schematic (b) free body diagram, (c) free body diagram in static condition

If x = x(t) denotes the displacement (m) of the mass m (kg) from its equilibrium position as a function of time t (s), the equation of motion for this system becomes, $m\ddot{x} + k(x+x\ ) - mg = 0$ where k =the stiffness of the spring (N/m), x = static deflection m = the spring under gravity load, g = the acceleration due to gravity (m/s2), $\ddot{x}$ = acceleration of the system. Applying static condition as shown in Fig. (c) the equation of motion of the system yields $m\ddot{x}+kx=0$

Unit –II: Electrostatics

Coulomb's Law – Intensity of Electric Field – Intensity due to a point charge – Electric Flux – Electric Potential – Electric Potential due to a Point Charge

Coulombs Law

According to **Coulomb's law**, the force of attraction or repulsion between two charged bodies is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. It acts along the line joining the two charges considered to be point charges.

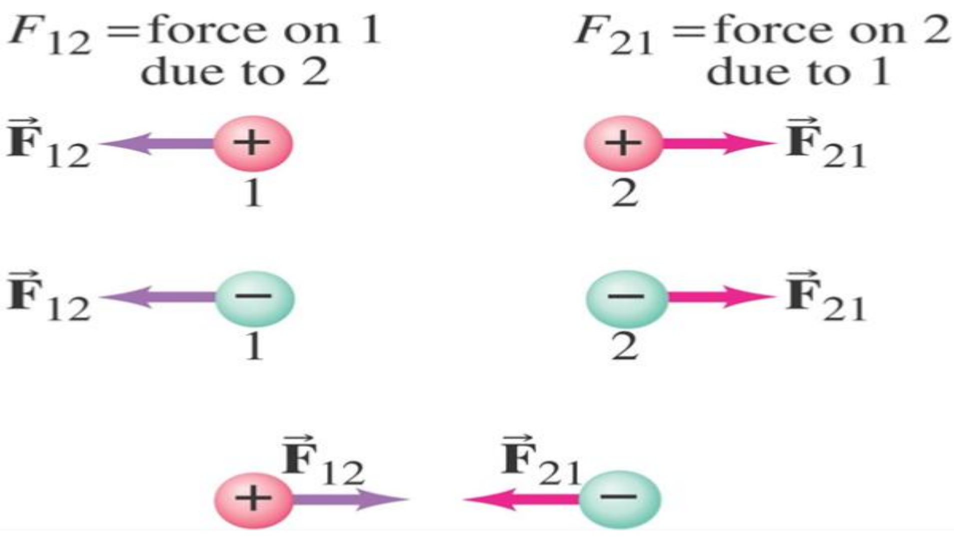
Coulomb's Law Formula

$$F = \frac{1}{4\pi\varepsilon} . \frac{q_1 . q_2}{d^2}$$

Where,

ε is absolute permittivity. In short, $F \propto q_1q_2/d^2$

This equation gives the magnitude of the force between two charges. The force is along the line connecting the charges, and is attractive if the charges are opposite, and repulsive if they are the same.



Unit of charge: coulomb, C. The proportionality constant in Coulomb's law is then: k = 8.99 x 109 N·m²/C². Charges produced by rubbing are typically around a microcoulomb: 1 μC = 10^{-6} C.

Electric field intensity

Electric filed or electric field intensity: The electric field or electric field intensity is defined as the electric force per unit charge.

It is given by $\boldsymbol{E} = \boldsymbol{F}/\ \boldsymbol{q}$

According to coulomb's law

$$F = \frac{Qq}{4\pi\varepsilon r^2}$$

Electric field

$$E = F/q$$

Substitute $\boldsymbol{F}$ value in above equation

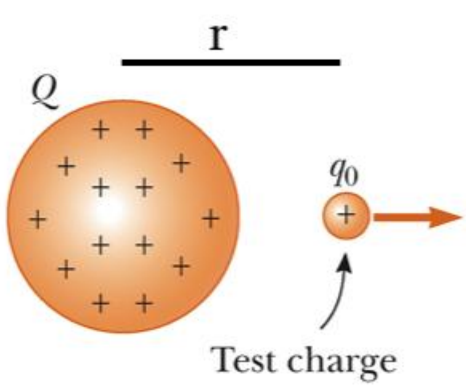
$$\boldsymbol{E} = \boldsymbol{Qq}\ /\boldsymbol{4\pi\varepsilon r2}\ /\boldsymbol{q}$$

$$E = \frac{Q}{4\pi\varepsilon r^2} v/m$$

Another unit of electric field is $\boldsymbol{Volts/meter}$.

Electric Field due to a point charge

E-field exerts a force on other point charges



$$\vec{E} = \frac{\overrightarrow{F}}{q_0} = \frac{k_e Q q^0}{r^2} / q^0$$

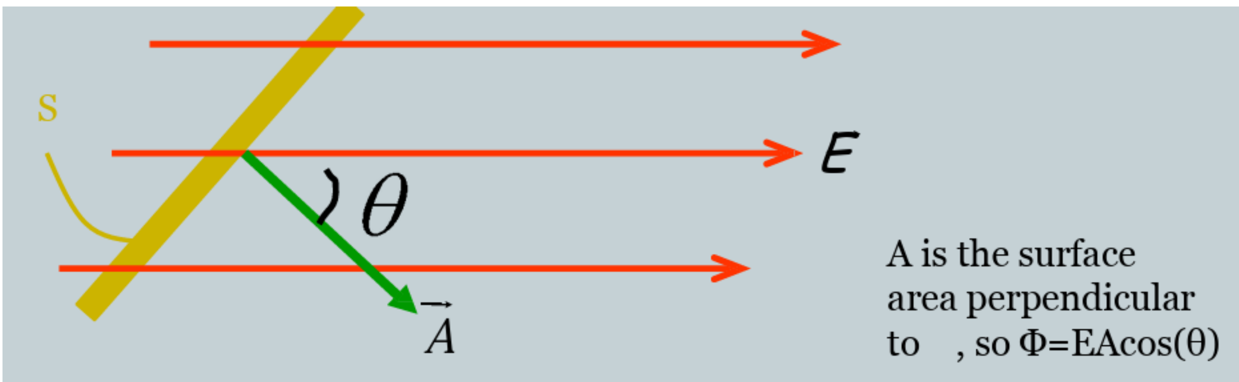
$$\overrightarrow{E} = \frac{K_e\, Q}{r^2}$$

$\overrightarrow{E}$ is a vector quantity Magnitude & direction vary with position--but depend on object w/ charge Q setting up the field. The electric field depends on Q, not q_0. It also depends on r. If you replace q_0 with $-q_0$ or $2q_0$, the strength & magnitude of the E-field at that point in space remain the same. The electrostatic FORCE, however, depends on Q AND q_0 as well as r.

Electric flux

Electric flux is the measure of the ―number of field lines passing through a surface S. For uniform: E . The number of field lines passing through perpendicular unit area will be prop ortional to the magnitude of Electric Field there" (Theory of Field Lines).

Electric Flux $\Phi_E = E. A$ $N \cdot m^2/C$



Electric Potential

Electrostatic potential at a point in space is the amount of work done in bringing a unit positive charge from infinity to that point in an electric field, without any acceleration. It is a scalar quantity and is denoted by V.

The formula for electrostatic potential due to a point charge at a distance from the charge is given by

$$V = \frac{Kq}{r}$$

where:

V = Electrostatic potential,

K = Coulomb's constant,

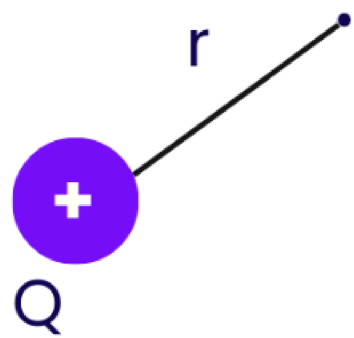
q = Source charge,

r = Distance from the source charge.

The SI unit of electrostatic potential is the volt (V). One volt is equivalent to one joule per coulomb (1 V = 1 J/C), which means that 1 volt represents the potential difference when 1 joule of work is done to move 1 coulomb of charge between two points in an electric field.

Electric potential to a point charge

Point charges, such as electrons, are among the fundamental building blocks of matter. Furthermore, spherical charge distributions (like on a metal sphere) create external electric fields exactly like a point charge. The electric potential due to a point charge is, thus, a case we need to consider. Using calculus to find the work needed to move a test charge from a large distance away to a distance of between work and potential from a point charge, and noting the connection between work and potential ($W = -q\Delta v$). it can be shown that the electric potential V of a point charge is



Charge range point

$$V = \frac{KQ}{r}\ Point\ charge$$

where k is a constant equal to $9.0 \times 10^9\ N.m^2/C^2$

The potential at infinity is chosen to be zero. Thus, V for a point charge decreases with distance, whereas E for a point charge decreases with distance squared

$$\boldsymbol{E = \frac{F}{q} = \frac{KQ}{r^2}}$$

Recall that the electric potential V for a point charge decreases with distance, whereas is a scalar and has no direction, whereas the electric field E is a vector. To find the voltage due to a combination of point charges, you add the individual voltages as numbers. To find the total electric field, you must add the individual fields as vectors, taking magnitude and direction into account. This is consistent with the fact that is closely associated with energy, a scalar, whereas force, a vector.

Unit –III: Electricity

Ohm's law – Resistance of a conductor – specific resistance – Heating effect of current and concept of electric power.

Ohms Law

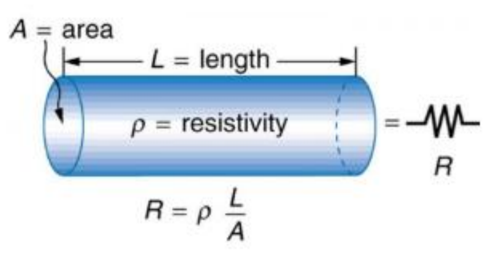
Ohm's law states that the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperatures remain constant. Mathematically, this current-voltage relationship is written as,

V = IR

An example of this is the filament of a light bulb, in which the temperature rises as the current is increased. In this case, Ohm's law cannot be applied. **The lightbulb filament violates Ohm's Law**.

Resistance of a conductor

Resistance of a conductor simply defined as when flow of current is opposed or resisted in a material it is known as resistance and effect of length and the radius on conductor can be given by $R = \frac{\rho l}{A}$ where l is the length of the conductor and A is the area o0f the conductor. Conductor Resistance is a measure of the difficulty to the pass an electrical current through it. Higher the resistance, lesser the current will flow though the conductor. Resistance of a conductor is influenced by conductor dimension, construction and conditions like temperature and resistivity.

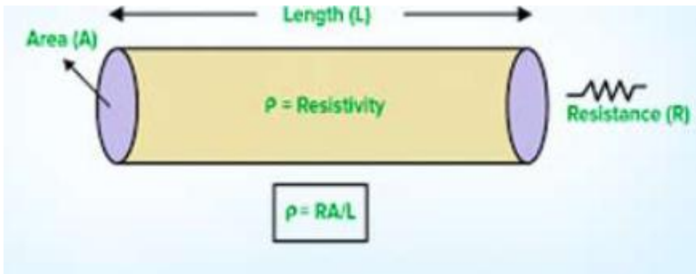


Resistance of a conductor

The resistance of an object depends on its shape and the material of which it is composed. The cylindrical resistor in Figure 1 is easy to analyze, and, by so doing, we can gain insight into the resistance of more complicated shapes. As you might expect, the cylinder's electric resistance R is directly proportional to its length L, similar to the resistance of a pipe to fluid flow. The longer the cylinder, the more collisions charges will make with its atoms. The greater the diameter of the cylinder, the more current it can carry (again similar to the flow of fluid through a pipe). In fact, R is inversely proportional to the cylinder's cross-sectional area A.

Specific resistance

Specific resistance, also known as resistivity, is an essential property of a material that quantifies its inherent ability to resist the flow of electric current.



Specific resistance, also known as resistivity, is an essential property of a material that quantifies its inherent ability to resist the flow of electric current. It is a fundamental parameter in the study of electrical conductivity and plays a crucial role in various electrical and electronic applications. Specific resistance is denoted by the symbol "ρ" (rho) and is measured in ohm-meters (Ω·m) in the International System of Units (SI).

Factors Affecting Specific Resistance:

Specific resistance depends on various factors, including:

Material Type: Different materials have different atomic and molecular structures, which significantly influence their specific resistance. Metals, for example, generally have low specific resistance due to their abundance of free electrons that can easily carry current. Insulating materials, on the other hand, have high specific resistance as they lack free charge carriers.

Temperature: Specific resistance tends to change with temperature for most materials. In the case of metals, resistance typically increases with rising temperatures, whereas for semiconductors, it often decreases.

Impurities and Alloying Elements: The presence of impurities or alloying elements can alter the specific resistance of a material. For instance, adding specific elements to a semiconductor can enhance its conductivity.

Crystal Structure: The crystal lattice structure of a material can influence how freely electrons can move, thus affecting its specific resistance.

Applications of Specific Resistance:

Specific resistance finds applications in various fields of electrical and electronic engineering:

Circuit Design: Understanding the specific resistance of materials is crucial for designing circuits with the desired electrical characteristics and avoiding excessive power losses.

Electrical Transmission: Knowledge of specific resistance is vital for designing efficient power transmission lines and cables that minimize energy losses during distribution.

Semiconductor Devices: In the design and manufacturing of semiconductor devices like transistors and diodes, specific resistance plays a key role in optimizing their performance.

Electrical Heating Elements: In applications where electrical heating is required, materials with suitable specific resistance properties are used to generate heat efficiently.

Materials Selection: Specific resistance is a key parameter considered when selecting materials for various electrical and electronic components.

Heating effect of the electric current and concept of electric power

Whenever electric current is passed through materials, it will discharge energy in the form of heat energy. This conversion of electrical energy into heat energy known as the heating effect of electric current. Though it is a loss of energy, this loss of energy is utilized for doing certain useful things, like we use iron boxes for pressing clothes, electric heaters for boiling water, etc. The heating effect of electric current is well explained with a mathematical description given by Joule's law. Joule's law says that the amount of heat generated is directly proportional to the current flowing through the wire and the resistance of the material. The heating effect of electric current is exhibited by Joule's law. Mathematically, Joule's law is given by $H = I^2Rt$ Where, H - The amount of heat produced

I - The amount of electricity passing through the wire

t - Time taken for heat generation

Application of the Heating Effect of Current

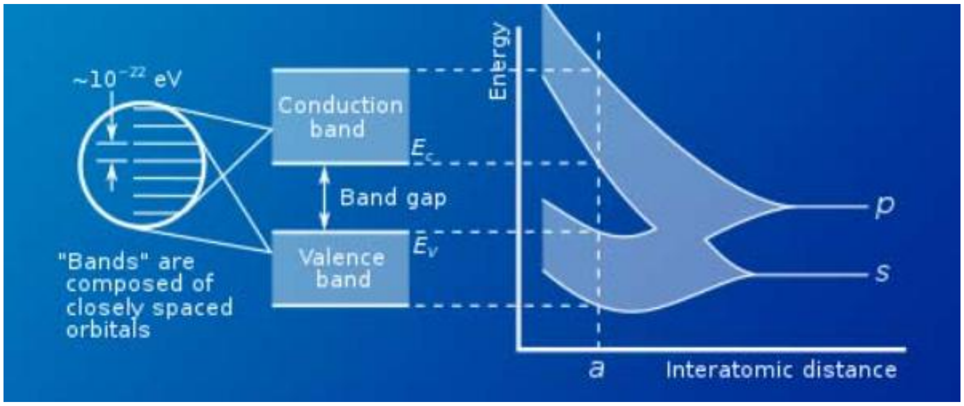
The electric bulb is one of the basic applications of heating effects of electricity. The tungsten filament used will discharge its energy as heat and light. The effect is well used in the electric iron boxes. Electric heaters are the most widely used domestic equipment for boiling waters.

Unit –IV: Semiconductor Physics

Energy bands – intrinsic and extrinsic semiconductor – p-n junction diode – characteristics of diode

Energy bands

Energy bands are a fundamental concept in the field of condensed matter physics and materials science. They play a crucial role in explaining the electronic behavior of materials, from insulators to conductors, and are a cornerstone of our understanding of how electrons move and interact within solids



Energy Bands Formation

In a solid material, numerous atoms are closely packed, resulting in the overlap and interaction of their electron energy levels. These interactions give rise to energy bands, which are ranges of allowed energy values that electrons can occupy. The two primary types of energy bands are the valence band and the conduction band.

Valence Band: The valence band is the lower energy band and is composed of the highest energy levels of the valence electrons – the electrons involved in chemical bonding. Valence electrons are tightly bound to their respective atoms and are not readily available for conducting electricity.

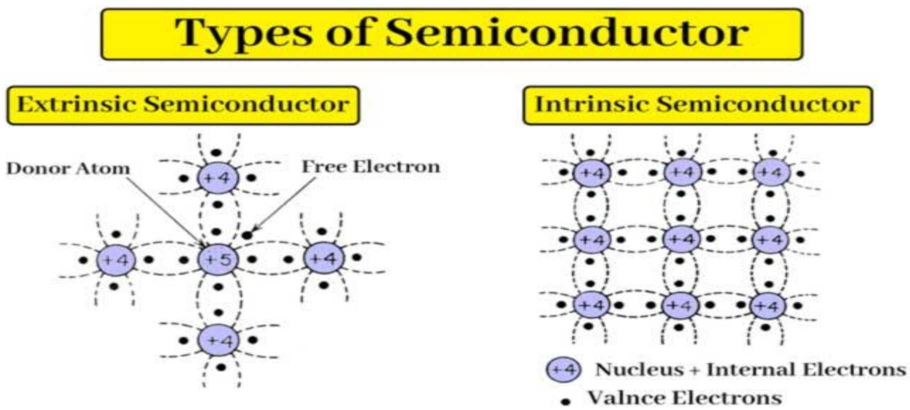
Conduction Band: Above the valence band lies the conduction band, which contains higher energy levels. Electrons in the conduction band are loosely bound to atoms and are free to move throughout the material. These mobile electrons are responsible for electrical conductivity and other electronic phenomena.

Intrinsic Semiconductors

An intrinsic semiconductor may be defined as one in which the number of conduction electrons is equal to the number of holes. Examples of such semiconductors are: pure germanium and silicon which have forbidden energy gaps of 0.72 eV and 1.1 eV respectively.

Extrinsic Semiconductors

Those intrinsic semiconductors to which some suitable impurity or doping agent or doping material has been added in extremely small amounts (about 1 part in 108) are called impure [or] extrinsic semiconductor.



Characteristics of Intrinsic and Extrinsic semiconductors

Characteristics	Intrinsic semiconductor	Extrinsic semiconductor
Purity	Pure semiconductor (with an impurity) is considered to have an intrinsic nature.	Such semiconductors are made by adding impurities to pure semiconductors.

Conductivity	Low	High
Use	They are not practically used	They are practically used in various applications.
Energy gap	Energy gap is small.	The energy gap is more than that in an intrinsic semiconductor.
Electrons Vs Holes	Number of electrons and holes are equal.	In N-type, electrons are in majority whereas in P-Type, holes are in majority.
Examples	Silicon, Germanium	For P-Type: Gallium, Aluminum, Boron For N-Type: Phosphorous, Antimony, Arsenic
Elements table	Group IV elements lie in this category.	Group III and V elements (as an impurity) are introduced in Group IV elements.

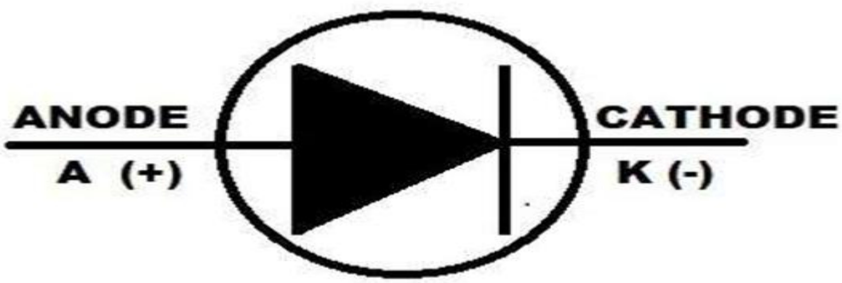
Conductivity Vs Temperature	Conductivity increases as temperature rises.	Conductivity mainly depends on the impurity added.

p-n junction diode

A diode is a device which only allows unidirectional flow of current if operated within a rated specified voltage level. A diode only blocks current in the reverse direction while the reverse voltage is within a limited range otherwise reverse barrier breaks and the voltage at which this breakdown occurs is called reverse breakdown voltage. The diode acts as a valve in the electronic and electrical circuit. A P-N junction is the simplest form of the diode which behaves as ideally short circuit when it is in forward biased and behaves as ideally open circuit when it is in the reverse biased.

Symbol of Diode

The name diode is derived from "di-ode" which means a device having two electrodes.



Symbol of p-n junction diode

Construction

The p-type forms anode and the n-type forms the cathode. These terminals are brought out to make the external connections. N-side will have a significant number of electrons, and very few holes (due to thermal excitation) whereas the p side will have a high concentration of holes and very few electrons. Due to this, a process called diffusion takes place. In this process free electrons from n side will diffuse (spread) into the p side and recombine with holes present there, leaving positive immobile (not moveable) ions in n side and creating negative immobile ions in p side of the diode. Hence, there will be uncovered positive donor ions in n-type side near the junction edge.

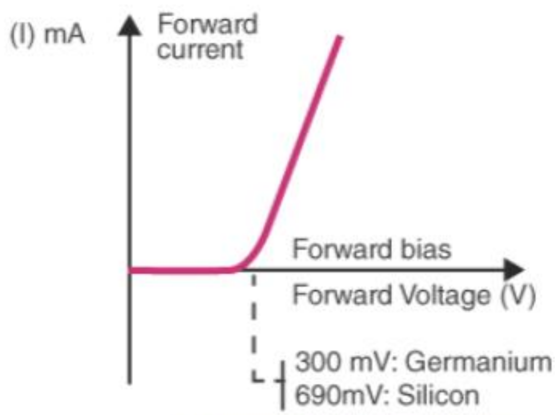
Characteristics of Diode

The following are the characteristics of the diode:

- Forward-biased diode
- Reverse-biased diode
- Zero biased diode

Forward-biased Diode

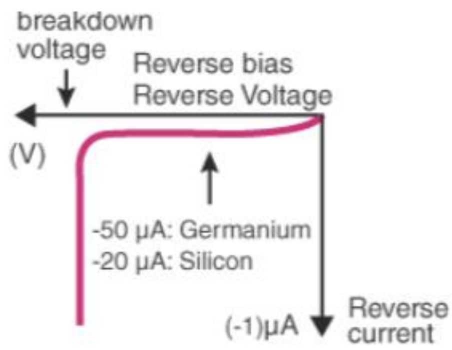
There is a small drop of voltage across the diode when the diode is forward-biased and the current is conducting. For silicon diodes, the forward voltage is 690mV and for germanium, 300mV is the forward voltage. The potential energy across the p-type material is positive and across the n-type material, the potential energy is negative.



Forward-biased diode

Reverse-biased Diode

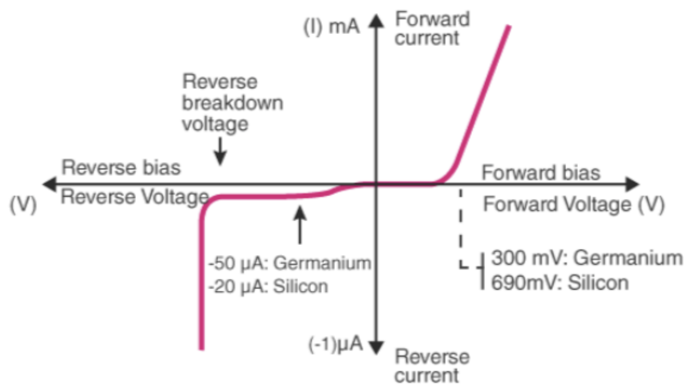
A diode is said to be reverse-biased when the battery's voltage is dropped completely. For silicon diodes, the reverse current is -20μA and for germanium, -50μA is the reverse current. The potential energy across the p-type material is negative and across the n-type material, the potential energy is positive.



Reverse-biased diode

Zero-biased Diode

When the diode is zero-biased, the voltage potential across the diode is zero.



VI characteristics of Diode

Unit –V: Superconductivity

Phenomenon of superconductivity – Type I superconductor – Type II superconductor – applications of superconductor.

The phenomenon of superconductivity

The concept of superconductivity remains the greatest hopefulness in modern technology for progress towards methods that reduce energy and electricity consuming. The field-induced superconductors were discovered about a decade before the discovery of high Critical Temperature (TC) superconductors (found in 1986), both types of field-induced materials are considered to be high critical temperature superconductors and superconductors of high value in science and engineering because they are important in physics and for its wonderful capabilities in technical applications.

Classification of the Superconductivity

There are several criteria by which superconductors are classified. The most common are:

a- By the theory of operation

b- By critical temperature

c- By material

d- Response to a magnetic field

By the theory of operation:

It is conventional if it can be explained by BCS theory or its derivatives, or unconventional, otherwise. The BCS theory is Bardeen-Cooper-Schrieffer theory (named after John Bardeen, Leon Cooper, John Robert Schrieffer) since the discovery of Heike Kamerlingh Onnes in 1911 was the first microscopic theory of superconductivity where the theory describes superconductivity as a microscopic effect produced by condensation of Cooper's pairs. The theory is also used in nuclear physics to describe the coupling reaction between nuclei in an atomic nucleus.

By critical temperature:

Low-temperature superconductors refer to materials whose temperature is below 30 K but a superconductor is generally considered to be superheated if it reaches a superconducting state above 30 K (-243.15 c°) While the materials that transition to superconductivity, when cooled with liquid nitrogen, is TC > 77 K.

By material:

Categories of superconducting materials include alloys (such as niobium-titanium, germanium-niobium, niobium nitride) or chemical elements (such as mercury Hg or lead Pb) and ceramics (YBCO and magnesium debride).

Types of Superconductors

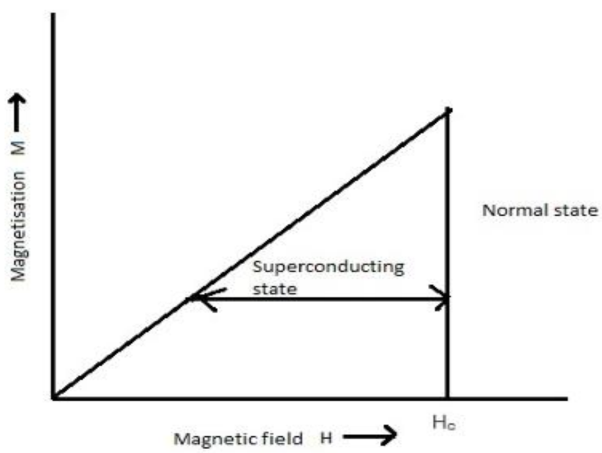
Depending upon the behavior in an external magnetic field, superconductors are divided into two categories:

1. Type-I superconductor or soft superconductor
2. Type-II superconductor or hard superconductor

Type-I Superconductor

Type-I superconductor acts as a perfect diamagnetic material and obeys Meissnar effect.

• As value of magnetic field (H) increases, magnetisation of superconductor also increases. Above critical magnetic field (H c) it turns into normal state.



Magnetisation curve for type-I superconductor

•This is reversible process. When value of applied field decreases, material expells magnetic field lines and retains to superconducting state. value of H

•Type-I superconductor allows magnetic field lines to penetrate at lower value of Hcc Therefore, it is also known as "Soft superconductor". Therefore, it is also known as "Soft superconductor".

• Mostly pure elements like Aluminum (Hc = 0.0105 Tesla), Zinc (Hc = 0.0054) etc. are examples of soft superconductors.

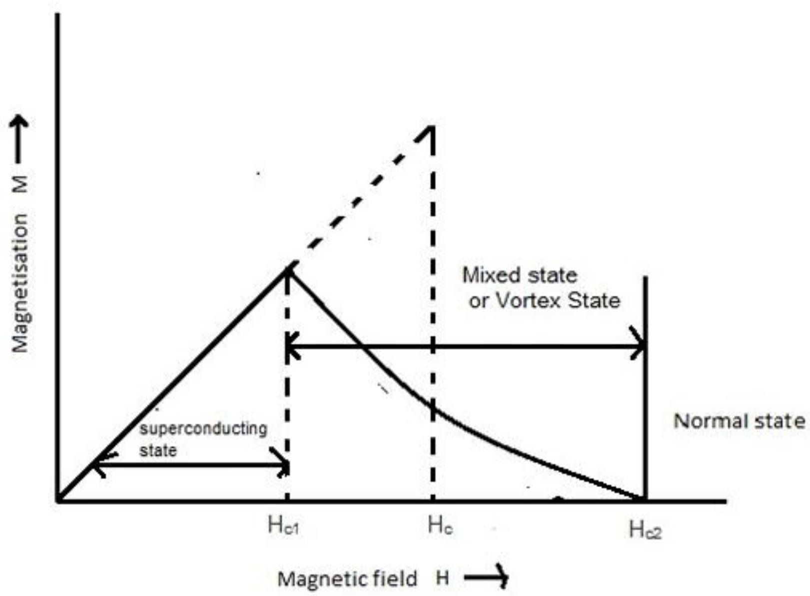
Type-II Superconductor

Type-II superconductors do not obey perfect Meissner effect.

•As value of magnetic field field (H) increases, magnetisation of superconductor increases. Upto H c1

•Above H c1 it shows perfect superconducting behavior. force of external magnetic field lines increases and it starts penetrating superconducting material. At Hc2 completely.

•The state between Hc1 and c2 material losts its superconductivity is known as "Vortex state" or "Mixed state".



•As to destroy superconductivity of type-II superconductor is difficult than type-I

•As to destroy superconductivity of type-II superconductor is difficult than type-I superconductor due to its high value of Hc , it is known as "Hard superconductor".

•Mostly alloys and ceramics like NbN (Hc = 8 x 10^6 10^3 Tesla) are examples of hard superconductors.

Applications of Superconductors

Some major application areas and benefits of superconductors are

Healthcare

MRI scanners use superconducting magnets to generate strong magnetic fields required for magnetic resonance imaging in medical diagnostics. SQUIDs (Superconducting Quantum Interference Devices) are very sensitive magnetometers used in magnetoencephalography to map brain activity.

Scientific Research

Particle accelerators like theLarge Hadron Collider use superconducting magnets to steer and focus particle beams due to their ability to create intense fields. High magnetic field experiments in physics rely on superconductors to generate the extremely strong magnetic fields required.

Industrial processing

Magnetic separation techniques utilise superconducting magnets to sort materials. Superconducting bearings allow frictionless, levitating rotation.

Monitoring

SQUID magnetometers are ultra-sensitive detectors of magnetic fields used in science, medicine and geomagnetic surveys.

Defence

Degaussing systems use superconducting coils to cancel ships' magnetic fields as protection against mines. Superconductive shields block electromagnetic pulses and radiation.