

CONTENTS	Page No
Some useful data	2
Vernier Calipers	3
Screw guage	5

I CYCLE EXPERIMENTS:

Expt. 01	:	Wavelength of Laser Light using a Semiconductor Laser.	7
Expt. 02	:	Planck's constant using LED's	9
Expt. 03	:	Dielectric constant	11
Expt. 04	:	Resistivity by Four probe technique	14
Expt. 05	:	Stefan's law	16
Expt. 06	:	Characteristics of Photodiode	18
Expt. 07	:	Series and parallel resonances in LCR	20
Expt. 08	:	Uniform Bending Experiment circuit	23

II CYCLE EXPERIMENTS

Expt. 09	:	Fermi energy	25
Expt. 10	:	Transistor Characteristics	27
Expt. 11	:	Ultrasonic interferometer	31
Expt. 12	:	Zener diode	33
Expt. 13	:	Newton's Rings Experiment	36
Expt.14	:	Planck's constant using photoelectric effect	38
		Model Question Bank	40

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SOME USEFUL DATA

Stefan's law:

Stefan's index = 4

Stefan's constant = $5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$

Planck's law

Wavelength of red LED = $\lambda_R = 6100 \text{ \AA}$

Wavelength of Yellow LED = $\lambda_Y = 5700 \text{ \AA}$

Wavelength of green LED = $\lambda_G = 5420 \text{ \AA}$

Wavelength of blue LED = $\lambda_B = 4000 \text{ \AA}$

Dielectric constant of a capacitor

$\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$,

l = Length of capacitor strip = 0.55 m,

B = Breadth of capacitor strip = $1.5 \times 10^{-2} \text{ m}$,

R = Resistance in the circuit = $33 \times 10^3 \Omega$,

d = Distance of separation of capacitor strips = $100 \times 10^{-6} \text{ m}$

Conversion factor:

$1 \text{ mm} = 10^{-3} \text{ m}$;

$1 \text{ mm}^2 = 10^{-6} \text{ m}^2$

$1 \text{ cm} = 10^{-2} \text{ m}$;

$1 \text{ cm}^2 = 10^{-4} \text{ m}^2$

$1 \text{ \AA} = 10^{-10} \text{ m}$

$1''$ (1 inch) = $2.54 \times 10^{-2} \text{ m}$

Boltzmann constant: $1.38 \times 10^{-23} \text{ J/K}$

i. Vernier Calipers

Aim : To determine the thickness of the given material.

Apparatus : Vernier Calipers, specimen material.

Formula : **i) For total reading:**

$$\text{T.R.} = \text{MSR} + (\text{CVD} \times \text{LC}) \text{ cm}$$

Where TR = Total Reading, cm
MSR = Main scale reading, cm
LC = Least count, cm
CVD = coincidence vernier scale division.

iii) For Least Count:

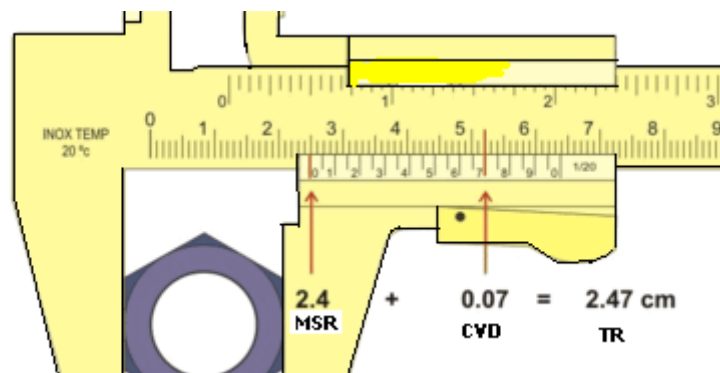
$$\text{Least count} = \frac{1}{Nn} = \frac{1}{10 \times 10} = 0.01 \text{ cm}$$

Where N = total no of divisions on the mainscale in 1 cm
n = total no of divisions on the vernier scale

OR

$$\text{Least count} = \frac{\text{Value of 1 Main Scale reading}}{\text{Total number of divisions in the vernier scale}} = \frac{\left(\frac{1}{10}\right) \text{ cm}}{10} = \frac{0.1 \text{ cm}}{10} = 0.01 \text{ cm}$$

FIGURE:



PROCEDURE:

- 1) The given specimen whose dimension is to be determined is held tightly between the two jaws of the calipers as shown in the diagram.
- 2) The Main scale reading (MSR) and the coinciding vernier scale division (CVD) are noted down.

- 3) The total reading TR is then calculated using the formula.
- 4) The experiment is repeated by taking readings at three different places of the specimen and in each case the total reading is found out and tabulated in the tabular column.
- 5) Then the mean value of total reading is calculated which gives the breadth of the given object.

OBSERVATIONS:

$$\text{Least count} = \frac{1}{Nn} = \frac{1}{10 \times 10} = 0.01 \text{ cm}$$

Where N = total no of divisions on the mainscale in 1 cm
 n = total no of divisions on the vernier scale

or

$$\text{Least count} = \frac{\text{Value of 1 Main Scale reading}}{\text{Total number of divisions in the vernier scale}} = \frac{\left(\frac{1}{10}\right) \text{ cm}}{10} = \frac{0.1 \text{ cm}}{10} = 0.01 \text{ cm}$$

Breadth of the specimen material:

Trial No.	MSR in cm	CVD	b = MSR + (CVD X LC) in cm
1			
2			
3			

Mean 'b' = x 10⁻² m

ii. SCREW GAUGE

Aim : To determine the diameter of a thin wire using a screw gauge.

Apparatus : Screw gauge, a thin wire

Formula : **i) For total reading:**

Where	T.R.	= PSR + (CHSD X LC) mm
	TR	= Total Reading, mm
	PSR	= Pitch scale reading, mm
	LC	= Least count, mm
	CHSD	= Corrected head scale Division
i.e.,	HSD	= HSD ± ZC
Where	HSD	= Head scale Division
	ZC	= Zero correction

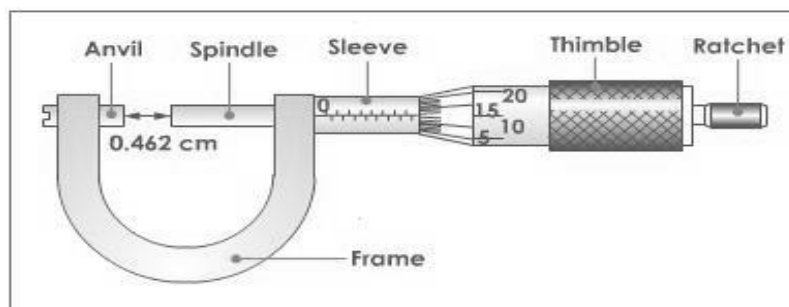
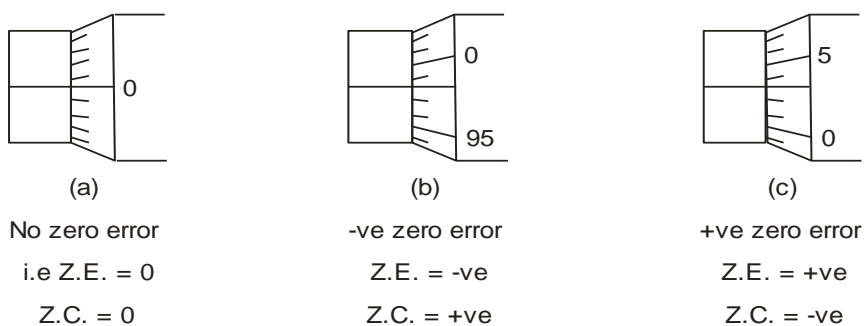
ii) For pitch:

$$\text{Pitch} = \frac{\text{No of divisions uncovered on the pitch scale}}{\text{No. of complete rotations given to the head scale}}$$

iii) For Least Count:

$$\text{Least Count (L.C)} = \frac{\text{Pitch}}{\text{Total no. of head scale divisions}} \text{ mm}$$

FIGURE:



PROCEDURE:

- 1) To start with the zero error and hence the zero correction of the screw gauge is found out as shown in figure.
- 2) The given wire whose diameter is to be determined is held tightly between the tip of the screw and the fixed end.
- 3) The pitch scale reading (PSR) and the coinciding head scale division (HSD) are noted down. Then the corrected HSD is find out using the relation, CHSD= HSD + ZC. This reading will be a mere number.
- 4) The total reading TR is then calculated using the formula. This gives the diameter of the given wire.
- 5) The experiment is repeated by taking readings at four different places of the wire and in each case the total reading is found out.
- 6) Then the mean value of total reading is calculated which gives the mean diameter of the given wire.

OBSERVATIONS:

No. of rotations given to the screw head =.....

No of divisions uncovered on the pitch scale =mm

$$\text{Pitch} = \frac{\text{No of divisions uncovered on the pitch scale}}{\text{No. of complete rotations given to the head scale}} = \dots\dots\dots\text{mm}$$

$$\text{Least Count (L.C)} = \frac{\text{Pitch}}{\text{Total no. of head scale divisions}} \text{mm}$$

Zero error =.....divisions.
 Zero correction = divisions.

Diameter of the thin wire:

Trial No.	PSR mm	HSD	Corrected HSD CHSD = HSD + ZC	Diameter 'd' in mm d= PSR + (CHSD X LC)
1				
2				
3				
4				

$$\text{Mean diameter 'd'} = \dots\dots\dots \times 10^{-3} \text{m}$$

Model Question Bank

1. WAVELENGTH OF LASER LIGHT USING A SEMICONDUCTOR LASER

1) What is diffraction of light?

The phenomenon of bending of light around the corners of small obstacles and hence its encroachment into the region of geometrical shadow.

2) Who discovered diffraction of light?

Prof Grimaldi discovered diffraction of light in 1665..

3) Mention the nature of light which explains the phenomenon of diffraction of light?

Wave nature of light which explains the phenomenon of diffraction of light.

4) Name the theory of light which explains diffraction.

Huygens wave theory of light explains diffraction.

5) What is a grating?

A grating is a device consists of a large number of parallel slits of the same width separated by equal opaque spaces. It is used in the field of spectroscopy.

6) How is grating made?

A grating is made by ruling equidistant fine and parallel lines on an optically flat glass plate by using a diamond point.

7) Who constructed the grating for the first time?

Joseph Fraunhofer was the first to construct a grating.

8) What is grating element?

Grating element or grating constant is the sum of the width of an interspaces and the width of a line.

9) The word LASER stands for what?

It is light amplification by stimulated emission of radiation.

10) What is basic principle of Laser?

Radiation interacts with matter under appropriate conditions. The interaction leads to an abrupt transition of the quantum system such as an atom or a molecule from one energy state to another. If the transition is from higher state to lower state is through stimulated emission then it gives rise to highly coherent light, which is the basic principle

11) What is induced absorption?

In induced absorption incident photon is absorbed as a result the system is elevated from a lower energy state to a higher energy state.

12) What is spontaneous emission?

Spontaneous emission is the emission of a photon, when a system transits from a higher energy state to lower energy state without the aid of any external agency.

13) What is stimulated emission?

It is the emission of a photon by a system, under the influence of passing photon of just the right energy due to which the system transits from higher energy states to a lower energy state. The photon thus emitted is called a stimulated photon and will have same phase, energy and direction of movement as that of the passing photon called the stimulated photon.

14) What is LASER?

It is a process by which a coherent, highly monochromatic and perfectly parallel beam is obtained.

15) What is population inversion?

It is an assembly of atoms in a system in which majority of the atoms are in the excited state. ie., there exists more number of atoms in the excited state than in the ground state.

16) What is meant by optical pumping?

It is the process of rising atoms from the ground state to an excited state by incidenting a photon of right energy on the system .

2. PLANCK'S CONSTANT USING LED

1) Which law explains correctly the distribution of energy in the spectrum of black body?

Planck's law of radiation explains correctly the distribution of energy and it is based on quantum theory of radiation.

2) What is the theory of Planck's, regarding radiation?

To account for the distribution of energy in the spectrum of black body radiation, Planck developed the quantum theory of radiation. According to this theory, radiation can be emitted or absorbed only in discrete units corresponds to an energy E given by $E=h\gamma$, γ is the frequency of radiation, h is Planck's constant. $h = 6.625 \times 10^{-34}$ J-s.

3) What is optoelectronics?

It is the technology that makes use of the principles of optics and electronics.

4) Name any two optoelectronic devices.

A light emitting diode and photo diode.

5) What is a photodiode?

A photodiode is a p-n junction diode in which the reverse saturation current increases when it is illuminated with light.

6) What is a laser diode?

Laser diode is a p-n junction diode which produces a coherent light as in laser.

7) What is the basic principle of LED?

In germanium and silicon semiconductors energy supplied produces electron-hole pair and energy released during recombination is dissipated as heat. The radiation is in infrared region. But in semiconductors like GaAs, a visible photon is emitted due to the recombination of an electron and a hole. This forms the basic principle of LED.

8) What are the uses of LED's?

They are used in the manufacture of signal lamps, display devices, calculators, indicator for power on overload or short circuit, used in burglar alarm system, CD players, optical fiber communication (OFC).

9) What is a laser diode?

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10) What are the uses of LED's?

They are used in the manufacture of signal lamps, display devices, calculators, indicator for power on overload or short circuit, used in burglar alarm system, CD players, optical fiber communication (OFC)

3. DIELECTRIC CONSTANT OF A CAPACITOR

1) What are dielectrics?

Dielectrics are insulators. They do not have free electrons and hence do not conduct electricity. The dielectric materials shows the polarization of charges. Ex: air, glass, plastic, mica, dry wood, water etc.,

2) Name the two types of molecules of a dielectric.

Polar molecules and non polar molecules.

3) What are polar molecules?

The molecules of a dielectric which act like tiny electric dipoles and possess a permanent dipole moment but get induced with dipole moment are called polar molecules.

4) What are non polar molecules?

The molecules of a dielectric which do not possess a permanent dipole moment but get induced with dipole moment in an electric field are called non polar molecules.

5) Name the two polar molecules?

Water (H₂O) & carbon monoxide (CO) are polar molecules.

6) Name the two non polar molecules.

Oxygen (O₂) & carbon dioxide (CO₂) are non polar molecules.

7) What is polarization of charges?

When a dielectric slab is placed in an electric field, the positive & negative charges induced on the opposite faces of a dielectric due to the electric polarization is called polarization of charges.

8) What is the effect of dielectric when it is placed in an electric field?

The net field inside the dielectric gets reduced.

9) What is dielectric break down?

The phenomenon due to which dielectric loses its insulating property and behaves like a conductor is called dielectric break down.

10) Define dielectric strength of a dielectric.

The maximum value of applied electric field above which dielectric break down occurs is called the dielectric strength of a dielectric.

It is expressed in kilo volt per millimeter.

- 11) **What do you understand by the statement that dielectric strength of air is 3 KV /mm?**
The maximum field that air at one atmosphere can withstand is 3 KV/mm or 3×10^6 V/m. Beyond this field air starts conducting.
- 12) **When can a dielectric be strongly polarized?**
A dielectric can be strongly polarized at lower temperature with stronger applied electric field.

5. STEFAN'S LAW

- 1) **State Stefan's law**
The amount of thermal radiation emitted per second per unit area of the surface of a black body is directly proportional to the fourth power of the absolute temperature.
- 2) **What is a perfect black body?**
A perfect black body is one which absorbs completely the radiations of all wavelength incident on it. Circuit's absorptance is equal to 1.
- 3) **What is black body radiation?**
A perfect black body is heated to a high temperature it emits radiation consisting of all possible wavelengths. The radiation thus emitted is called the black body radiation. It is also called full or total radiation.
- 4) **Define emissive power of a body.**
Emissive power of a body at a particular temperature is defined as the total energy radiated per second.
- 5) **Define Emissivity.**
Emissivity is defined as the ratio of the emissive power of a body to the emissive power of a black body at the same temperature.
- 6) **Can a perfect black body realized in practice?**
A perfect black body can not be realized in practice.
- 7) **Name the black body generally used for accurate experiment work.**
Ferry black body designed by Ferry.
- 8) **What is radiation of heat?**
The process of transfer of heat from one place to another along a straight line without affecting an intervening medium is called radiation.
- 9) **What is thermal radiation?**
The energy emitted by body in the form of radiation by virtue of its temperature is called thermal radiation of energy.
- 10) **What is the speed with which thermal radiation travels?**

Thermal radiation travels with a speed of light i.e, 3×10^8 m/s.

11) Can thermal radiation travel through a vacuum?

Yes thermal radiation can travel through a vacuum.

12) What is infrared radiation?

Infrared radiation is nothing but thermal radiation.

13) Name an instrument used to detect thermal radiation.

Radiometer or Barometer is used to detect thermal radiation.

14) Define absorptive power of a body.

It is the ratio of the amount of thermal radiation absorbed by the body in a certain time to the total amount of thermal radiation incident in it in the same time, denoted by 'a'.

15) Define transmission coefficient of a body.

It is the ratio of amount of thermal radiation transmitted by the body in certain time to the total amount of thermal radiation incident on it in the same time, denoted by 't'.

16) Define reflection coefficient of the body.

It is the ratio of amount of thermal radiation reflected by the body in certain time to the total amount of thermal radiation incident on it in the same time denoted by 'r'.

17) What is the surface temperature of the sun as calculated by using the Stefan's law?

It is 5770 K.

18) Which law explains correctly the distribution of energy in the spectrum of black body?

Planck's law of radiation explains correctly the distribution of energy and it is based on quantum theory of radiation.

19) What is the theory of Planck's, regarding radiation?

To account for the distribution of energy in the spectrum of black body radiation, Planck developed the quantum theory of radiation. According to this theory, radiation can be emitted or absorbed only in discrete units corresponds to an energy E given by $E=h\gamma$, γ is the frequency of radiation, h is Planck's constant. $h = 6.625 \times 10^{-34}$ J-s.

6. PHOTODIODE CHARACTERISTICS

1) What is a photodiode?

Photodiode is a two terminal junction diode in which the reverse saturation current changes when it's reverse biased junction is illuminated by suitable wavelength of light.

2) On which principle the photodiode works?

When a p-n junction is reverse biased, a small amount of reverse saturation current is due to thermally generated electron-hole pairs. The number of these minority charge carriers, depends on the intensity of light incident on the junction.

3) How photodiode is different from LED?

In Photodiode the illuminated light produce a reverse saturation current but in LED's a suitable biasing current produce a photons of suitable frequency.

4) **What factors we must consider while selecting photodiode?**

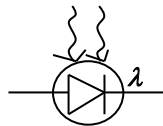
While selecting a photodiode for the required purpose it is necessary to know

- i) Wavelength of light for which it is sensitive.
- ii) Operating voltage.
- iii) Switching time and mounting.

5) **What are the applications of Photodiode?**

Photodiodes are used in detection, demodulation, switching, logic circuits, character recognition, optical communication equipments, encoders etc.

6) **Write the symbol of photodiode?**



7) **What is optoelectronics?**

It is the technology that makes use of the principles of optics and electronics.

8) **Name any two optoelectronic devices.**

A light emitting diode and photo diode.

1. SERIES AND PARALLEL RESONANCE CIRCUIT

1) **What is the function of A.F. oscillator?**

An A.F oscillator is a device which can produce sinusoidal waveforms of any desired frequency ranging from 20Hz to 20 KHz.

2) **What is meant by resonance?**

When the applied frequency matches with the natural frequency of a body, the amplitude of vibration becomes maximum. This phenomenon is called resonance.

3) **What do you mean by sharpness of resonance?**

It is a measure of the rate of fall of current amplitude from its maximum value at resonance frequency to on either side of it.

4) **What is resonance frequency?**

The frequency at which the resonance occurs is called resonance frequency.

5) **What are forced vibrations?**

Forced vibrations are the vibrations in which a body vibrates with a frequency other than its natural frequency under the influence of an external force.

6) **What is bandwidth of series circuit?**

The range of frequencies between the cutoff frequencies is called bandwidth.

7) **Define quality factor of a series circuit.**

The ratio of a resonant frequency of a circuit to its bandwidth is called quality factor.

8) Why should maximum value of current be divided by $\sqrt{2}$ for finding bandwidth?

At lower and upper cutoff frequencies, the current amplitude become $1/\sqrt{2}$ times the current amplitude at resonance and also, the r.m.s. value of current is given by

$$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}}.$$

9) Why is the series circuit called as acceptor circuit?

Because it accept one frequency component out of the input signals having different frequencies. The accepted frequency is equal to its own resonance frequency.

10) Why parallel resonance circuit is called a rejecter circuit?

Because it rejects the signal having same frequency as its own frequency.

11) What is the importance of series resonance circuits?

For high frequency A.C in radio communications, a series resonance circuit is used. LCR circuits are used in frequency filter circuits like high pass filter, low pass filter and band pass filter.

8. Uniform Bending Experiment

1) Define stress and strain and state their units?

The magnitude of the attractive or repulsive forces between molecules of a body per unit area is called stress. It is measured in N/m^2 .

The change of shape or the fractional change of size of a body by a given set of forces or couples is called strain. Strain has no unit.

2) State Hooke's law and define Modulus of Elasticity?

The stress is proportional to the strain within the elastic limits is called Hooke's law.

The ratio of any stress to the strain is called modulus of elasticity. It is measured in N/m^2 .

3) Define the different types of moduli of elasticity?

There are three moduli in use.

i) Young's modulus:- The ratio of longitudinal stress to longitudinal strain, within the elastic limits is called young's modulus of the material. Its unit is N/m^2 .

ii) Bulk modulus:-When a uniform pressure is applied over the whole surface of a body, it produces a uniform compression. The compression is proportional to the pressure, and the ratio of pressure to the volume strain is called bulk modulus. It is measured in N/m^2 .

iii) Rigidity modulus :- It is the ratio of shear stress to the shear strain. Its unit is N/m^2 .

4) List the different stages of elastic properties of matter?

When a load is continuously increased in the case of wire, it reaches a different elastic stages like: i)elastic limit ii)permanent set iii) breaking stress and iv) yield point.

5) What is poisson's ratio? What is its unit?

Within elastic limits there is a complete proportionality between the lateral strain and the longitudinal strain is called poisson's ratio. It has no unit.

6) How is bending of a beam related to young's modulus?

When a beam is bent by an applied couple, its longitudinal filaments are lengthened on the convex side and shortened on the concave, and thus the resistance which the beam offers to bending, will depend upon young's modulus for the material.

7) What is a cantilever?

When one end of a horizontal beam is fixed and the other end is free, it is called a cantilever.

9. FERMI ENERGY

1) What is Fermi level?

The highest energy level in the valence band occupied by electrons in a crystal at absolute zero of temperature is called Fermi level.

2) What is Fermi energy?

The energy corresponding to the Fermi level is called Fermi energy.

3) What is the importance of Fermi energy?

Electrical conduction takes place only when electrons acquire energy above the Fermi energy.

4) What is Fermi factor?

Fermi factor is the probability of occupation of a given energy state for a material in thermal equilibrium.

5) What is the probability of occupation for $E < E_F$ at $T=0$ K?

The probability of occupation $f(E) = 1$ for $E < E_F$ at $0K$.

6) What is the probability of occupation for $E > E_F$ at $T=0$ K?

The probability of occupation $f(E) = 0$ for $E > E_F$ at $0K$.

7) What is the probability of occupation at ordinary temperatures?

For $E = E_F$ the probability of occupation $f(E) = 1/2$ at ordinary temperatures.

8) What is Fermi temperature (T_F)?

It is the temperature at which the average thermal energy of the free electrons in a solid becomes equal to the Fermi energy at 0^0K . At this temperature gas can be considered degenerate. It depends on mass of fermions and energy.

9) What is Fermi velocity?

The velocity of the electrons which occupy the Fermi level is called the Fermi velocity V_F . It is measured by $V_F = \sqrt{2E_F / m}$

10) What is the unit for Fermi energy?

Its unit is eV.. 1eV is the energy possessed by electron when unit charge is accelerated through a potential of 1Volts. $1eV = 1.6 \times 10^{-19}C \times 1V = 1.6 \times 10^{-19}J$.

11) What is the formula for Fermi factor?

$$\text{It is calculated by } f(E) = \frac{1}{e^{(E-E_F)/k_B T} + 1}$$

12) What is the relation between E_F & T_F ?

$E_F = k_B T_F$, where k_B is Boltzmann constant.

13) What is meant by Fermi Dirac distribution?

It is the representation which depicts the details of distribution of electrons among the various available energy levels of a material under thermal equilibrium conditions. Fermi factor is called a Fermi Dirac distribution function.

14) What are the factors on which E_F depends?

E_F depends on the material and the temperature.

15) Are the energy levels lying above E_F are empty at 0 K?

Yes, they are empty, but below E_F are filled.

16) How many electrons are there in each energy level?

According to Paul's exclusion principle, there are 2 electrons are there in each energy level.

17) State Paul's exclusion principle?

It states that no two electrons having same quantum number can occupy the same energy levels in same time.

18) What is meant by mean free path (λ)?

It is the average distance traveled by the conduction electrons between successive collisions with lattice ions. It is measured in m.

19) What is meant by collision time (τ)?

The average time that elapse between two successive collisions of an electron with the lattice points is called mean collision time.

20) What is meant by relaxation time (τ_r)?

Due to sudden disappearance of an electric field across a metal the average velocity of its conduction electrons decays exponentially to zero. And the time required in this process for the average velocity to reduce to $1/e$ times its value just when the field is turned off, is known as relaxation time.

21) What is the meant by drift velocity?

The velocity of the electron in the steady state in an applied electric field is called the drift velocity(m/s).

22) If the dimension of the wire is changed will it affect the value of E_F ?

No. E_F depends on the temperature & material but not on the dimension.

23) From where does the Fermi level concept come from?

It comes from Fermi Dirac statistics.

24) What is the importance of Fermi energy?

It helps to understand electrical & thermal properties of solids. It explains why electrons do not contribute significantly to the specific heat of solids at room temperature T . it gives information about the velocity of electrons which participate in ordinary electrical conduction.

25) What is the effect of atomic number Z on E_F & T_F ?

As Z value decreases E_F & T_F increase.

10. TRANSISTOR CHARACTERISTICS

1) What is a transistor?

A transistor is a semiconductor device consisting of two P-N junctions back to back. It has 3 doped regions and its main action is amplification.

2) Name the 3 regions in a transistor.

They are emitter, base and collector.

3) Which region of the transistor is very highly doped?

Emitter of the transistor is very highly doped.

4) Name the 3 regions of a transistor in the decreasing order of 1) Doping 2) their size.

1) Emitter, collector, base 2) collector, emitter, base.

5) How is emitter region different from collector?

Emitter is more heavily doped than the collector.

6) What is the role of emitter, base and collector of a transistor?

Emitter supplies a large number of majority charge carriers of current through the device.

Base controls the flow of charges through the device.

Collector collects the majority charge carriers supplied by the emitter.

7) How many depletion regions are there in the body of a transistor?

There are two depletion regions in a transistor.

8) What is the normal biasing of a diode in a transistor?

Emitter-base diode is forward biased, while the collector-base diode is reverse biased.

9) What is the direction of conventional current through the body of a NPN transistor?

It is from emitter to base to the collector.

10) What is the significance of arrow mark in the symbol of a transistor?

The arrow mark is always on the emitter and it signifies the direction of conventional currents.

11) What is the relation between transistor currents?

The emitter current (I_E) is always equal to the sum of base current (I_B) and collector current (I_C). i.e, $I_E = I_B + I_C$

12) Why transistor is current control device?

By controlling the base current, the outgoing collector current can be controlled for the given emitter current. Hence a transistor is current control device.

13) Define α of a transistor for DC current.

It is defined as the ratio of change in collector current to the change in emitter current

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

14) Define β of a transistor for DC current.

It is defined as the ratio of change in collector current to the change in base current

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

15) Give the relation between α and β of a transistor.

$$\alpha = \frac{\beta}{1+\beta} \quad \text{or} \quad \beta = \frac{\alpha}{1-\alpha}$$

16) Why the term transistor is so named?

Transistor term is derived from the combination of two words “transfer” and “resistor”. When transistors are used in circuits the variations in the low resistance input circuit are transferred to high resistance output circuit.

12. ZENER DIODE

1) What is a zener diode?

A heavily doped P-N junction which has a sharp breakdown voltage is called as a zener diode.

2) What is diode?

The diode is a semiconductor device having p-n junction.

3) On what factor does the breakdown voltage of a zener diode depends?

The breakdown voltage of a zener diode depends upon the amount of doping. If the diode is heavily doped, the depletion layer will be thin and consequently the breakdown of the junction will occur at a lower reverse voltage.

4) What is breakdown voltage?

When the reverse bias of a zener diode is increased, a critical voltage is reached at which the reverse current increases sharply to a high value. This critical voltage is called breakdown voltage.

5) What is the difference between an ordinary diode and a zener diode?

- i) A zener diode is like an ordinary diode except that it is properly doped so as to have a sharp break down voltage.
- ii) It has a sharp breakdown voltage called zener voltage.
- iii) When forward biased, zener diode characteristics are just that of ordinary diode.
- iv) A zener diode is always reverse biased.

6) Why zener diode is always reverse biased?

Because it utilize reverse characteristics for acting like a voltage regulator.

7) Mention the uses of zener diode.

A zener diode is used as a voltage regulator to provide a constant voltage from a source whose voltage vary over sufficient range.

8) What do you mean by Characteristics of a Zener Diode?

A Graph showing the variation of voltage applied across the terminals of a diode to the corresponding current is called characteristics of a diode. In case of junction diodes, there are two types of characteristics, forward and reverse characteristics.

9) Explain the flow of current in zener diode under reverse biasing condition.

In case of reverse biasing condition, the external field is established in a direction such as to help internal field. Under this biasing the holes in P- region and electrons in N- region are pushed away from the junction with the result that the depletion or barrier layer is thickened and hence increases the potential barrier, therefore, the flow of current stops. Only a few thermally generated minority carriers produce a very small current.

10) Explain the flow of current in zener diode under forward biasing condition.

In the case of forward biasing condition, the zener diode behaves like an ordinary p-n junction diode. In this case the external field is established in a direction such as to oppose the internal field. The external field is much stronger than internal field. In this arrangement holes move along the external field from p-region to n-region and electrons move opposite to the field from n-region to p-region, that is, the majority carriers from each side move across the junction. The potential barrier or depletion layer at the junction wiped out and a substantial current flows depending upon the density of n- and p- carriers.

11) What do you mean by doping?

The process of introducing the impurity in a semiconductor is called doping.

12) What is Zener breakdown?

If the reverse potential across the zener diode is increased beyond a certain value, the current increases very rapidly due to zener breakdown. Zener breakdown occurs when the applied electric field or potential is so high that the valence band electrons are pulled out to the conduction band in large numbers resulting in breakdown. Thus, a zener breakdown, direct rupture of covalent bonds take place by thermally generated carriers having acquired high energy due to strong electric field.

13) What do you mean by avalanche breakdown?

When the reverse voltage is made sufficiently high the thermally generated electrons and holes acquire high energy from the applied potential and make ionizing collisions with the atoms of the crystal. These collisions produce further electrons, which in turn collide with further atoms. The commutative effect of such collisions results in the breakdown of the junction. Due to this avalanche multiplication the reverse current increases abruptly to high value. This is called avalanche breakdown and may damage the junction.

14) What are the differences between avalanche breakdown and zener breakdown?

In general zener breakdown occurs below 8V and avalanche breakdown occurs at higher voltages (~20 V). The Zener breakdown is characterized by the soft knee, whereas avalanche breakdown is hard knee type. Zener breakdown voltage has a negative temperature coefficient, while the avalanche breakdown voltage exhibits positive temperature coefficient.

15) How the width of the depletion region in the reverse biased diode varies with the impurity concentration.

The width of the depletion region of a reverse biased diode varies as the square root of the impurity concentration.

16). How the value of the potential barrier depends on the amount of doping of the semiconductor?

The value of potential barrier decreases with heavy amount of doping of the semiconductor.

17). Why the silicon diode is preferred compare to germanium diode?

Silicon diodes are preferred compare to germanium diodes because of its higher temperature to current capability.

18). Under what condition a zener diode behaves like an ordinary p-n junction diode?

A zener diode behaves as an ordinary p-n junction diode when it is used in forward bias conditions.

19). What is the main application of a zener diode?

An important application of zener diode is its use as voltage regulator. The regulating action takes place due to the fact that in reverse breakdown region; a very small change in voltage produces a very large change in current.

13. Newton's Rings experiment

1) What do you mean by interference of light?

The modification in the distribution of light energy due to the superposition of two or more waves of light is called interference of light.

2) What are the conditions for sustained interference?

- i. The light waves superposing at a point must have the same wavelength or same frequency.
- ii. The amplitude of superposing light waves should be equal or almost equal.
- iii. The waves superposing should either have the same phase or constant phase difference.
- iv. Light sources must be very narrow and very close to each other.

3) Explain the term coherent sources?

Any two sources of light continuously emitting light waves having zero or constant phase difference are called coherent sources.

4) How Newton's rings are formed?

When a monochromatic light falls normally on Plano convex lens and glass plate set, the light reflected by the lower surface of the lens and upper surface of the glass plate superpose to produce interference pattern. This circular interference pattern is called Newton's rings.

5) Why is the central ring is dark?

The path difference of $(\lambda/2)$ is introduced between the two rays as a result of the phase change of π for ray reflects from glass plate and no phase change for the ray reflects from plano convex lens. The central ring is dark because the two interfering rays have a path difference $(\lambda/2)$ in spite of the fact that the thickness is zero.

6) How to obtain central bright spot in Newton's rings?

By interpose a film of refractive index less than that of the material of the lens and greater than that of the material of the plate. Then the path difference between the two rays becomes λ produces central bright spot.

7) On what factors does the diameter of a ring depend?

It depends on the wavelength of the light and the radius of curvature of the plano-convex lens.

8) What are the applications of Newton's rings?

It is used to i) determine wavelength of unknown light source.

ii) to determine radius of curvature of given lens.

iii) Refractive index of given liquid using the formula
$$\mu = \frac{(D_{n+m}^2 - D_n^2)_{air}}{(D_{n+m}^2 - D_n^2)_{liquid}}$$

ENERGY GAP OF A SEMICONDUCTOR

1. **Name the three class of materials in respect of motion of electrons through them.**
They are conductors, insulators and semiconductors.
2. **How many electrons are there in the orbit of conductors, semiconductors and insulators?**
Conductors have one electron, semiconductors have four electrons and insulators have eight electrons.
3. **What is an energy band?**
The collection of very closely spaced energy levels is called an energy band.
4. **What is a valance band?**
The highest energy band which is completely filled at zero K temperature (0 K) is called valence band.
5. **What is conduction band?**
The band lying with next to the valence band which may be partially filled or completely empty is called conduction band.
6. **What is forbidden energy band?**
The energy gap between the valence band and conduction band is called forbidden energy band. It is from uppermost level of valence band to lowermost level of conduction band.
7. **What is Fermi level?**
The highest energy level in the valence band occupied by electrons in a crystal at a absolute zero of temperature is called the Fermi level.
8. **What is Fermi energy?**
The energy corresponding to the Fermi level is called Fermi energy.
9. **What is the value of a conductivity of a semiconductor at zero Kelvin?**
At zero Kelvin conductivity of a pure semiconductor is zero.
10. **How does the resistance of a semiconductor vary with temperature?**
The resistance of a semiconductor decreases exponentially with increase in temperature.
11. **Which is the most suitable choice of a semiconductor in modern electronics?**
It is the silicon semiconductor.
12. **What is an intrinsic semiconductor?**
An intrinsic semiconductor is a pure semiconductor in which the number of electrons is equal to the number of holes.
13. **What is an extrinsic semiconductor?**
An extrinsic semiconductor is an impure or doped semiconductor in which the number of electrons is not equal to the number of holes.

14. What is doping of a semiconductor?

It is a process of adding impurity atoms to an intrinsic semiconductor crystal to increase its electrical conductivity.

15. What is dopant?

The impurity added to an intrinsic semiconductor is called a dopant.

16. Name the two types of extrinsic semiconductors.

The two types of extrinsic semiconductors are n-type and p-type semiconductors.

17. Doping of silicon with indium leads to which type of semiconductor?

It leads to p-type of semiconductor.

18. What type of dopant is used to obtain a n-type semiconductor?

Pentavalent atoms like P, As, Sb, Bi are the dopant used to obtain a n type semiconductors.

19. What type of dopant used to obtain p-type semiconductors?

Trivalent atoms like B, In, Al, Ga, are the dopant used to obtain p-type semiconductor.

20. What is a hole in a semiconductor?

The vacancy of an electron in the valence band is called a hole in a semiconductor. It acts as a positive charge.

21. What is the electrical state of an n-type or a p-type semiconductor?

Either an n type or a p type semiconductor is electrically neutral.

22. Name the majority carriers in a p type semiconductor.

Holes are the majority carriers in a p type semiconductor.