19BEBME241 **Semester-II**

Engineering Physics (Theory and lab.) **7H-5C**

Instruction Hours/week: L:3T:1P:3 **Marks:** Internal:**40**External:**60**Total:**100**

End Semester Exam:3 Hours

(i) Theory

Course Objective:

- To inculcate the basics of properties of matter and its applications.
- To study the basics of sound and ultrasonics with appropriate applications.
- To disseminate the fundamentals of thermal and quantum physics and their applications.
- To introduce the concepts of light, laser and fiber optics for diverse applications.
- To impart the basic knowledge of crystal and its various crystal structures.

Course Outcomes

Upon completion of this course, the students will be able

1. Develop knowledge on the basics of properties of matter and its applications.
2. List the concepts of sound, ultrasonics and their applications.
3. Analyse the concepts of thermal properties of materials and advanced physics concepts of quantum theory
4. Develop knowledge on the basics of light, laser, fiber optics and their applications.
5. Understand the basics of crystals and their structures.
6. Apply the knowledge gained from this course to solve the relevant problems in engineering stream.

UNIT I - PROPERTIES OF MATTER

Elasticity: Hooke's law, stress-strain diagram – types of moduli of elasticity – basic definitions, relation connecting the moduli (Derivation)-factors affecting elastic modulus and tensile strength–Poisson's ratio- Torsional pendulum- bending of beams - bending moment – uniform and non-uniform bending - I-shaped girders.

UNIT II - ACOUSTICS AND ULTRASONICS

Classification of sound - loudness and intensity - standard intensity and intensity level - decibel - reverberation- reverberation time- sound absorbing materials - factors affecting acoustics of buildings: focusing, interference, echo, echelon effect, resonance, noise and their remedies. Ultrasonics: production - magnetostriction and piezoelectric methods - industrial applications – Non-destructive testing- pulse echo system through transmission and reflection modes – scan displays.

UNIT III - THERMAL AND QUANTUM PHYSICS

Thermal expansion - thermal stress - expansion joints - bimetallic strips - thermal conductivity- heat conductions in solids – flow of heat through compound media – Forbe's and Lee's disc method: theory and experiment- Introduction to quantum theory – Black body radiation-Laws - dual nature of matter and radiation – de Broglie wavelength, uncertainty principle –Schrödinger's wave equation – time dependent and time independent equations – physical significance of wave function - particle in one dimensional box- degenerate and non-degenerate states.

UNIT IV - APPLIED OPTICS

Interference - Michelson interferometer: construction, working, determination of wave length and thickness - anti-reflection coating - air wedge and its applications - Lasers – principle and applications – Einstein's coefficients – CO_2 laser - semiconductor lasers: homo junction construction and working, Holography – applications. Optical fibres – classification (index & mode based) - principle and propagation of light in optical fibres - acceptance angle and numerical aperture - fibre optic communication system, fibre optic sensors.

UNIT V - CRYSTAL PHYSICS

Single crystalline, polycrystalline and amorphous materials – Single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices - interplanar distance for a cubic crystal –Effective number, atomic radius, coordination number and packing factor for SC, BCC, FCC, HCP- crystal imperfections: point defects, line defects, surface defects, Burger's vector.

SUGGESTED READINGS

7. Gaur R.K. and Gupta S.L, 2013 Engineering Physics, DhanpatRai Publications.
8. PalanisamyP.K, (2006)Engineering Physics, Scitech Publications (P) Ltd.
9. ArumugamM , (2000)Engineering Physics, Anuradha Publications.
10. SerwayR.A and Jewett J.W, (2010)Physics for Scientists and Engineers with Modern Physics, Thomson Brooks/Cole Publishing Co.
11. Tipler P.A. and MoscaG.P, (2007)Physics for Scientists and Engineers with Modern Physics, W.H.Freeman.
12. MarkertJ.T., Ohanian, H. and Ohanian M., (2007)Physics for Engineers and Scientists, W.W.Norton& Co.

(ii) Laboratory

Course Objective:

- To learn the basic concepts in physics relevant to different branches of Engineering and Technology.
- To study the concept of semiconductor and conductivity.
- To learn the properties of materials.

Course Outcome:

1. Familiarize the properties of material and basic concepts in physics.

LIST OF EXPERIMENTS – PHYSICS

1. Torsional pendulum - Determination of rigidity modulus of wire and moment of inertia of disc

2. Non-uniform bending - Determination of young's modulus

3. Uniform bending – Determination of young's modulus

4. Lee's disc Determination of thermal conductivity of a bad conductor

5. Potentiometer-Determination of thermo e.m.f of a thermocouple

6. Laser- Determination of the wave length of the laser using grating

7. Air wedge - Determination of thickness of a thin sheet/wire

8. Optical fibre -Determination of Numerical Aperture and acceptance angle

9. Ultrasonic interferometer – determination of the velocity of sound and compressibility of liquids

10. Determination of Band gap of a semiconductor.

11. Spectrometer- Determination of wavelength using grating.

12. Viscosity of liquids-Determination of co-efficient of viscosity of a liquid by Poiseuille's flow

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established under Section 3 of UGC Act 1956)

COIMBATORE – 641021

FACULTY OF ENGINEERING

DEPARTMENT OF SCIENCE AND HUMANITIES

LECTURE PLAN

Subject : ENGINEERING PHYSICS

Code : 18BEBME202

Unit No.	List of Topics	No. of Hours
UNIT I	**PROPERTIES OF MATTER**	
	Elasticity –Three types of modulus of elasticity	1
	Basic definitions, relation connecting the moduli	1
	Factors affecting elastic modulus and tensile strength	1
	Poisson's ratio- Torsional pendulum	1
	Tutorial	1
	Bending of beams - bending moment	1
	Uniform and non-uniform bending	1
	I-shaped girders	1
	Stress due to bending in beams	1
	Tutorial	1
	TOTAL	**10**
UNIT – II	**ACOUSTICS AND ULTRASONICS**	
	Classification of sound - loudness and intensity	1
	Standard intensity and intensity level - decibel	1
	Reverberation- reverberation time- sound absorbing materials	1
	Factors affecting acoustics of buildings: focusing, interference, echo, echelon effect, resonance,noise and their remedies.	1
	Tutorial	1
	Ultrasonics: production - magnetostriction and piezoelectric methods	1
	Industrial applications – non-destructive testing	1
	Pulse echo system through transmission and reflection modes	1
	Scan displays	1

	Tutorial	1
	TOTAL	**10**
UNIT – III	**THERMAL AND MODERN PHYSICS**	
	Thermal expansion - thermal stress - expansion joints	1
	Bimetallic strips - thermal conductivity- heat conductions in solids	1
	Flow of heat through compound media	1
	Forbe's and lee's disc method: theory and experiment	1
	Tutorial	1
	Introduction to quantum theory – black body radiation	1
	Dual nature of matter and radiation – de broglie wavelength	1
	Uncertainty principle –schrödinger's wave equation – time dependent and time independent equations	1
	Particle in one dimensional box, physical significance of wave function.	1
	Tutorial	1
	TOTAL	**10**
UNIT – IV	**APPLIED OPTICS**	
	Interference - Michelson interferometer: construction, working, determination of wave length and thickness	1
	Anti-reflection coating - air wedge and its applications	1
	Lasers – principle and applications – Einstein's coefficients	1
	Tutorial	1
	Co_2laser	1
	Semiconductor lasers: homo junction construction and working – applications	1
	Optical fibres – classification (index & mode based) - principle and propagation of light in optical fibres	1
	Acceptance angle and numerical aperture	1
	Fibre optic communication system.	1
	Tutorial	1
	TOTAL	**10**
	CRYSTAL	
	Single crystalline, polycrystalline and amorphous materials	1
	Single crystals: unit cell, crystal systems, bravais lattices, directions and planes in a crystal,	1

UNIT – V	Miller indices	1
	Tutorial	1
	Interplanar distance for a cubic crystal	1
	Coordination number and packing factor for sc, bcc,	1
	Coordination number and packing factor for fcc, hcp	1
	Coordination number and packing factor for hcp	1
	Crystal imperfections: point defects, line defects,surface defects	1
	Tutorial	1
	TOTAL	**10**
	TOTAL NO OF HOURS	**50**

TEXT BOOK& REFERENCES:

1. Gaur R.K. and Gupta S.L, 2013 Engineering Physics, DhanpatRai Publications,
2. Palanisamy P.K, (2006)Engineering Physics, Scitech Publications (P) Ltd,
3. ArumugamM , (2000)Engineering Physics, Anuradha Publications,
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5. Tipler P.A. and Mosca G.P, (2007)Physics for Scientists and Engineers with Modern Physics, W.H.Freeman,
6. Markert J.T., Ohanian, H. and Ohanian M., (2007)Physics for Engineers and Scientists, W.W.Norton& Co.

WEBSITES:

1. https://www.youtube.com/watch?v=EzcWpOFJ6P4
2. https://www.youtube.com/watch?v=x1-SibwIPM4
3. https://www.youtube.com/watch?v=TcmGYe39XG0
4. www. nptel.ac.in

STAFF IN-CHARGE **HOD**

UNIT 1

PROPERTIES OF MATTER

PART- A

Important Formula's

Stress = $\frac{Deforming\ force}{Area}$ = $\frac{F}{A}$ (N/m^2)

Strain = $\frac{Change\ in\ dimension}{Original\ dimension}$

Hooke's Law

$$\frac{Stress}{Strain} = \text{E (constant)}$$

Young's Modulus

Y = $\frac{Linear\ stress}{Linear\ strain}$ (Nm^{-2})

Rigidity modulus

n = $\frac{Tangential\ stress}{Shearing\ strain}$ (Nm^{-2})

Bulk modulus

$$K = \frac{Volume\ stress}{volume\ strain} \quad (Nm^{-2})$$

Twisting couple per unit twist $\mathbf{C = \frac{\pi n \theta r^4}{2l}}$

Young's modulus of the cantilever $\mathbf{Y = \frac{4Mgl^3}{bd^3\ y}}$

Rigidity modulus of the wire by Torsion pendulum $\mathbf{n = \frac{16\pi ml(d_2^2 - d_1^2)}{(T_2^2 - T_1^2)r^4}}$ (Nm^{-2})

Uniform bending method, Young's modulus of the beam $\mathbf{Y = \frac{3}{2}\frac{Mgal^2}{bd^3y}}$ (Nm^{-2})

Non-Uniform bending method, Young's modulus of the beam $\mathbf{Y = \frac{Mgl^3}{4\ bd^3y}}$ (Nm^{-2})

1. **Define Stress and its unit.**

- The restoring force acting per unit area of the body is called the stress.
- This restoring force is equal and opposite to the applied force F. Therefore, stress is also defined as the applied deforming force per unit area of the body.

$$\text{Stress} = \frac{Deforming\ force}{Area} = \frac{F}{A} \quad (\text{N/m}^2)$$

2. What are types of stresses?

- It is found that a deforming force may change length or shape or volume of the body. Accordingly, there are three types of stresses namely (i) Linear stress (ii) Shearing Stress (iii) Volume stress.

3. Define strain and its unit.

- The change in dimension or shape of a body due to the deforming force results in strain.
- It is defined as the ratio of change in dimension to the original dimension.

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

i.e.,strain has no unit.

4. What are types of strains?

According to the changes take place in length, area (shape) and volume, there are three types of strains namely,

- Linear Strain (change in length per unit length)
- Shearing strain (change in area per unit area)
- Volume strain (change in volume per unit volume)

5. State Hooke's Law.

- It states that "within elastic limit, the stress development in the body is directly proportional to the strain produced in it"

$$\text{Stress} \propto \text{Strain}$$

$$\frac{Stress}{Strain} = \text{E (constant)}$$

- In other words, the ratio between stress and strain is a constant.

6.What are types of Moduli of elasticity?

- Young's Modulus corresponding to linear strain.
- Rigidity modulus corresponding to shearing strain.
- Bulk modulus corresponding to volume strain.

7. Define Young's Modulus of elasticity and mention its unit.

- Within the elastic limit, the ratio of linear stress to linear strain is called Young's modulus of electricity.

$$Y = \frac{Linear\ stress}{Linear\ strain} \quad (\text{Nm}^{-2})$$

8. Define rigidity modulus and mention its unit.

- Within the elastic limit, the ratio of the tangential stress to shearing strain is called rigidity modulus.

$$n = \frac{Tangential\ stress}{Shearing\ strain} \quad (\text{Nm}^{-2})$$

9. Define Bulk modulus and mention its unit.

- Within the elastic limit of a body, the ratio of volume stress to volume strain is called bulk modulus of elasticity.

$$K = \frac{Volume\ stress}{volume\ strain} \quad (\text{Nm}^{-2})$$

10. What is I Shape Girder?

- A girder is a metallic beam supported at its two ends by pillars or on opposite walls. It should be so designed that it should not bend too much or break under its own weight. The cross section of beam is in the form of letter I.

11. What are advantages of I shape girder?

- As the layers of the beam at the upper and bottom are subjected to maximum stress more material must be needed there to withstand the strain.

  - As the stress around the neutral layer is small, material in these regions can be removed without loss of efficiency. This would save economy (cost of material of the girder).

- This type of cross- section provides a high bending moment and a lot of material is saved.

- 'I' form of girders are made of steel as they have high young modulus.

12. Define Poisson's ratio.

It is defined as the ratio between the lateral strain per unit stress (β) to the longitudinal strain per unit stress (α), within the elastic limits.

Poisson's ratio (σ) = $\frac{lateral\ strain}{linear\ strain}$ **=** $\frac{\beta}{\alpha} =$ **a constant**

13. List out the factors affecting elasticity.

Some bodies lose their elastic property even within the elastic limit, due to the elastic fatigue.

Apart from the fatigue some materials will have change in their elastic property because of the following factors.

1. effect of stress

if a material is subjected to large no.of cycles of stresses, it loses its elastic property even within the elastic limit. Hence working stress should be kept lower than the tensile strengthening and the safety factor.

2. Effect of annealing

   Annealing is a process by which the material is heated to a very high temperature and then it is slowly cooled. This will create large crystal size grains, which reduces the elastic property.

3. Change in temperature

   Elastic property of the materials changes with the temperature. Normally the elasticity increases with the decrease in temperature and vice-versa.

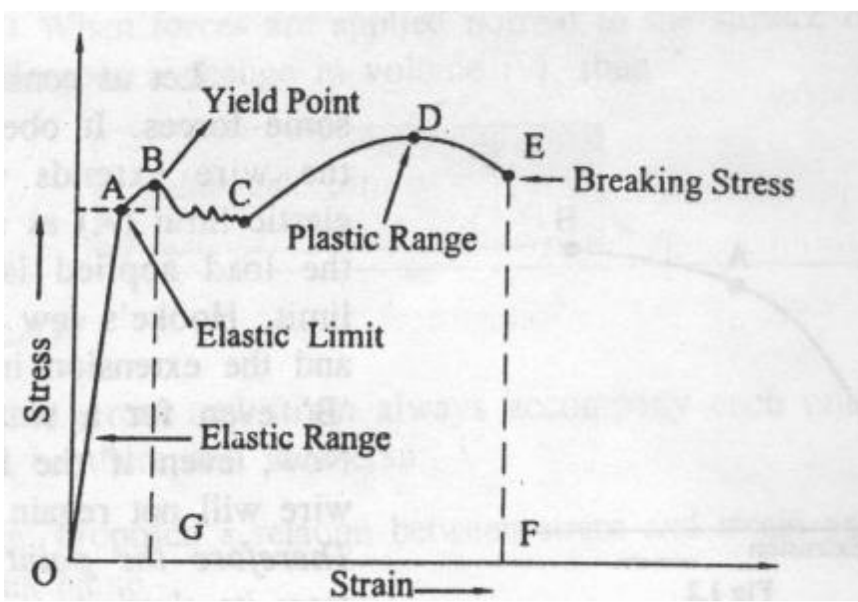
4. Presence of impurities

   The addition of impurities produces variation in the elastic property of the materials. The increase and decrease of elasticity depends on the type of impurity added to it.

5. Nature of crystals.

   The elasticity also depends on the types of the crystals, whether it is a single crystal or poly crystals. For a single crystal the elasticity is more and for a poly-crystal the elasticity is less.

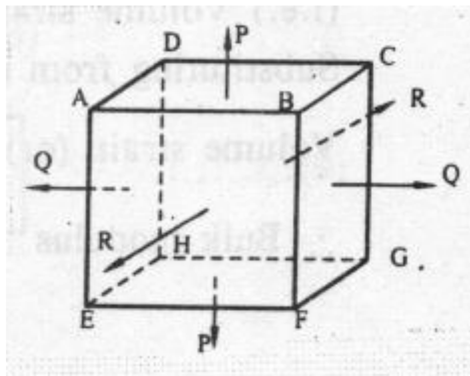
14. Draw stress -strain diagram.



PART – B

1. **Derive relations between elastic moduli.**

Let us consider n unit cube of a material. Let P,Q and R are the three stresses acting perpendicular to the three faces ABCD, ADHE, and ABFE of the cube.



Each one of the one of these stresses produce an elongation in its own direction and compression along the other two perpendicular direction.

Let α be the increase in length per unit stress and β be the decrease in length per unit stress.

The elongation along the direction P= αP

The contraction along the direction P due to stress Q = βQ

The contraction along the direction P due to stress R = βR

The net elongation along the direction P= e = αQ-βP-βR -------- 1

The net elongation along the direction Q= f = αP-βQ-βR -------- 2

The net elongation along the direction R= g = αR-βP-βQ -------- 3

We can express the three elastic constants, Y,K and n in terms of α and β as follows.

Condition1.

If only the stress 'P' acts and Q=R=0

Substitute this in equation 1

Linear strain e = αP

Youngsmodulus $Y = \frac{stress}{linear\ strain} = \frac{P}{\alpha P} = \frac{1}{\alpha}$

$$\alpha = \frac{1}{Y} \text{ ---------------------------- } \mathbf{4}$$

Condition 2.

If all stress and equal P=Q=R

Substitute this in equation 1

strain e = (α-β-β)P = (α-2β)P -----------------------5

From the standard relation, volume strain is equal to 3e

Volume strain = 3 (α-2β)P

Bulk modulus K = $\frac{Bulk\ stress}{Bulk\ strain} = \frac{P}{3(\alpha - 2\beta)P}$

$$\alpha - 2\beta = \frac{1}{3K} \text{ ---------------------------- } \mathbf{6}$$

Condition 3.

Suppose the P=-Q and R=0

Substitute this in equation 1

strain e = αP-β(-P) = (α+β)P -----------------------7

From the standard relation, angle of shear ad strain,

Shearing strain ϕ =2e

Substituting value of e from eqn. 7

ϕ =2 (α+β)P ------------------------------8

Rigidity modulus n = $\frac{Tangential\ stress}{Shearing\ strain} = \frac{P}{\phi}$

$$n = \frac{P}{2(\alpha + \beta)P} = \frac{1}{2(\alpha + \beta)}$$

$$\alpha + \beta = \frac{1}{2n} \text{ ---------------------------- } \mathbf{9}$$

1. **Relation between Y, n and K**

From eqn. 9

$$\alpha + \beta = \frac{1}{2n}$$

$$2\alpha + 2\beta = \frac{1}{n} \qquad \text{--------------}\mathbf{10}$$

Adding equ. 10 and 6

$$3\alpha = \frac{1}{n} + \frac{1}{3K}$$

$$\alpha = \frac{1}{3}\left[\frac{3K+n}{3Kn}\right] \qquad \text{-------------}\mathbf{11}$$

Equation eqn. 4 and 11 we have

$$\frac{1}{Y} = \frac{3K+n}{9Kn}$$

$$Y = \left[\frac{9Kn}{3K+n}\right] \qquad \text{---------}\mathbf{12}$$

2. **Relation between n, K and σ**

$$3\beta = \frac{1}{2n} - \frac{1}{3K}$$

$$3\beta = \frac{3K-2n}{6Kn} \qquad \text{------------------}13$$

$$\beta = \frac{3K-2n}{18Kn}$$

Substituting for α and β from eqn. 11 and 13 in poisons ratio

$$\sigma = \frac{\frac{3K-2n}{18Kn}}{\frac{9Kn}{3K+n}} = \frac{3K-2n}{6K+2n} \qquad \text{------------------}14$$

3. **Relation between Y, n and σ**

Dividing eqn. 9 by 4 we have

$$\frac{\alpha+\beta}{\alpha} = \frac{\frac{1}{2n}}{\frac{1}{Y}}$$

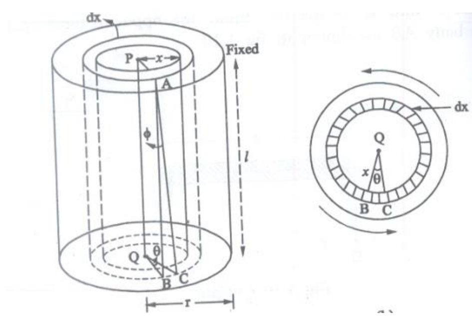
$$1+\frac{\beta}{\alpha} = \frac{Y}{2n}$$

$$1+\sigma = \frac{Y}{2n} \quad \text{----------15}$$

$$\sigma = \frac{Y}{2n} - 1$$

2. Derive an expression for the twisting couple on a wire.

- Consider a cylindrical wire of length l and radius r fixed at one end. It is twisted through an angle ɵ by applying couple to its lower end. Now, the wire is said to be under torsion.



- Due to elastic Property of the wire, an internal restoring couple is set up inside the wire. It is equal and opposite to the external twisting couple (applied).
- The cylinder is imagined to consist of a large number of thin hollow coaxial cylinders.
- Consider one such cylinder of radius x and thickness dx.
- AB is a line parallel to PQ on the surface of this cylinder. As the cylinder is twisted, the line AB is shifted to AC through an angle BAC = Φ

Shearing strain or Angle of shear = Φ

Angle of twist at the free end = θ

From the figure (1.11 (b))

$$BC = x\theta = l\Phi$$

$$\Phi = \frac{x\theta}{l} \qquad \text{-----(1)}$$

Rigidity modulus $n = \frac{S\ hearing\ Strees}{Shearing\ strain}$

Shearing stress = n x Shearing strain = $n\Phi$

$$= \frac{nx\theta}{l}$$

But, Shearing stress = $\frac{Shearing\ force}{Area\ over\ Which\ the\ force\ act}$

Shearing force = Shearing stress X area over which the force acts

area over which the force acts = $\pi(x + dx)^2 - \pi^2$

$$= \pi\,(x^2 + 2xdx + dx^2) - \pi\,x^2$$

$$= \pi x^2 + 2\pi xdx + \pi dx^2 - \pi x^2$$

(dx^2 *term is neglected since it is very small*)

$$= 2\pi xdx$$

Hence , shearing force $F = \frac{nx\theta}{l} 2\pi xdx$

$$= \frac{2\pi n\theta}{l} x^2\,dx \text{-----(2)}$$

The moment of this force about the axis PQ of the cylinder.

= Force X Perpendicular distance

$$= \frac{2\pi n\theta}{l} x^2 dx \quad X \quad x$$

$$= \frac{2\pi n\theta}{l} x^3 dx \text{----(3)}$$

The moment of the force acting on the entire cylinder of radius r is obtained by integrating the expression (3) between the limits x = 0 and x = r.

Hence ,twisting couple

$$C = \int_0^r \frac{2\pi n\theta}{l} x^3 dx$$

$$\frac{2\pi n\theta}{l} \int_0^r x^3\, dx = \frac{2\pi n\theta}{l} \left[\frac{x^4}{4}\right]$$

Applying the units ,we have

$$= \frac{2\pi n\theta}{l} \left[\frac{r^4}{4} - 0\right]$$

$$\mathbf{C = \frac{\pi n\theta r^4}{2l}}$$

This twisting couple required to produce a twist of unit radian in the cylinder is called torsional **rigidity for material of the cylinder.**

<u>Hollow Cylinder :</u>

For a hollow cylinder of the same length l and of inner radius r_1 and outer radius r_2

$$C = \int_{r1}^{r2} \left(\frac{2\pi n\theta}{l}\right) x^3 dx$$

$$= \left(\frac{\pi n\theta}{2l}\right) (r_2^4 - r_1^4)$$

Twisting couple per unit twist of the cylinder

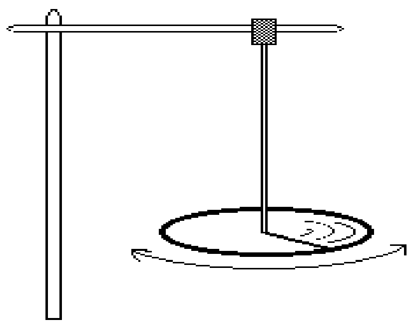
$$\mathbf{C = \frac{\pi n}{2l} (r_2^4 - r_1^4)}$$

3. Define torsional pendulum. Give theory of this pendulum. How it is used to find the rigidity modulus of the wire.

- **A circular metallic disc suspended using a thin wire that executes torsional oscillation is called torsional pendulum.**

Description

- A torsional pendulum consists of a metal wire suspended vertically with the upper end fixed. The lower end of the wire is connected to the centre of a heavy circular disc.



When the disc is rotated by applying a twist, the wire is twisted through an angle θ. Then, the restoring couple set up in the wire

$$= C\theta \qquad \text{----(1)}$$

If the disc is released, it oscillates with angular velocity $\frac{d\theta}{dt}$ in the horizontal plane about the axis of the wire. These oscillations are known as torsional oscillations.

$$\text{Applied couple} = I\frac{d^2\theta}{dt^2} \text{---(2)}$$

In equilibrium, applied couple = restoring couple

$$I\frac{d^2\theta}{dt^2} = C\theta \qquad \text{----(3)}$$

Hence, the motion of the disc being simple harmonic motion, the time period of the oscillation is given by

$$T = 2\pi\sqrt{\frac{Displacement}{Acceralation}}$$

$$= 2\pi\sqrt{\frac{\theta}{\frac{C}{I} X\ \theta}}$$

$$\mathbf{T = 2\pi\sqrt{\frac{I}{C}}} \text{----(4)}$$

Experiment

- A circular disc is suspended by a thin wire, whose rigidity modulus is to be determined. The top end of the wire is fixed firmly in a vertical support.
- The disc is then rotated about its centre through a small angle and set it free. It executes torsional oscillations.
- The time taken for 20 complete oscillations is noted. The experiment is repeated and the mean time period (T) of oscillation is determined.
- The length L of the wire is measured. This length is then changed by about 10 cm and then the experiment is repeated. The readings for five or six different lengths of wire are measured.

The disc is removed and its mass and diameter are measured.

The time period of oscillation is

$$\mathbf{T = 2\pi\sqrt{\frac{I}{C}}} \qquad \textbf{----(1)}$$

Squaring on both sides, we have

$$T^2 = 2^2 \pi^2 \left[\sqrt{\frac{I}{C}}\right] \quad \text{---- (2)}$$

$$T^2 = \frac{4\pi^2}{C} I \quad \text{---- (3)}$$

Substituting couple per unit twist $C = \frac{\pi n r^4}{2l}$ in eqn (4),

We have

$$T^2 = \frac{4\pi^2 I}{\frac{\pi n^4}{2l}} = \frac{2l \ X \ 4\pi^2}{\pi n r^4}$$

Rearranging the equation (5)

The rigidity modulus of the material of the wire

$$n = \frac{8\pi I l}{r^4 T^2}$$

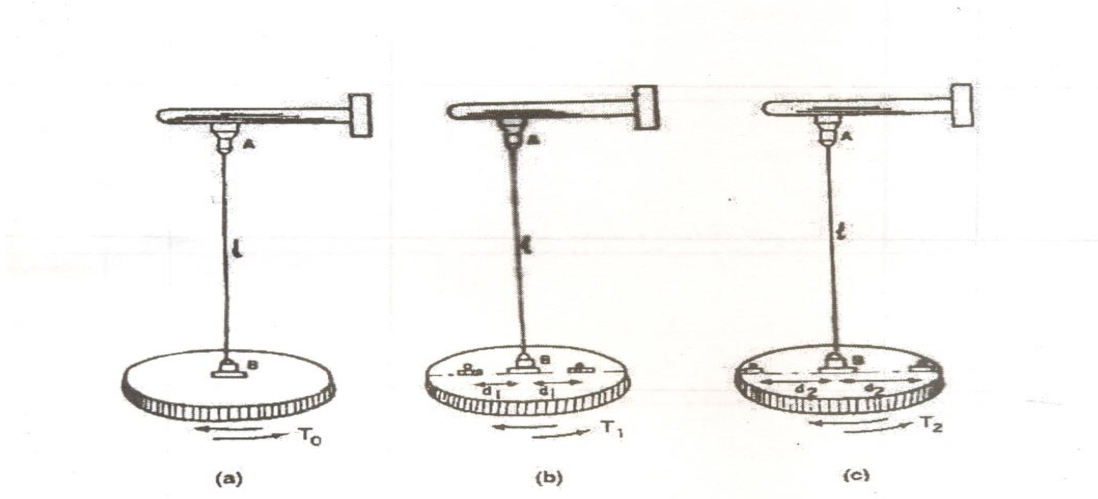
where

M - Mass of the circular disc

R - Radius of the disc.

Rigidity modulus by Torsion Pendulum (Dynamic torsion method)

The torsion pendulum consists of a steel or brass wire with one end fixed in an adjustable chuck and the other end to the centre of a circular disc as shown in figure.



The experiment consists of three parts.

First the disc is set into torsional oscillations without any cylindrical masses on the disc. The mean period of oscillation 'T_o' is found out.

$$T_0 = 2\pi \sqrt{\frac{I_0}{C}}$$

Where I_0 - moment of inertia of the disc about the axis of the wire.

$$T_0^2 = 4\pi^2 \frac{I_0}{C} \text{-----}(1)$$

Two equal cylindrical masses (each mass m equal to 200 gm) are placed symmetrically along a diameter of the disc at equal distance d_1 on the two sides of the centre of the disc.

Mean time period of Oscillation T_1 is found.

Then, $$T_1 = 2\pi \sqrt{\frac{I_1}{C}}$$

$T_1^2 = 4\pi^2 \frac{I_1}{C}$-----(2)

Then, by the parallel axis theorem, the moment of inertia of the whole system is given by

$I_1 = I_0 + 2\text{i} + 2\text{m}\, d_1^2$----- (3)

Substituting the value of I_1 in eqn. (2)

$T_1^2 = \frac{4\pi^2}{C}(I_0 + 2\text{i} + 2\text{m}\, d_1^2)$ ---- (4)

Mean time period of oscillation 'T_2 ' is found out in this case also.

$$T_2 = 2\pi \sqrt{\frac{I_2}{C}}$$

$$T_2^2 = 4\pi^2 \frac{I_2}{C} \qquad (I_2 = I_0 + 2\text{i} + 2\text{m}\, d_2^2)$$

$$T_2^2 = \frac{4\pi^2}{C}(I_0 + 2\text{i} + 2\text{m}\, d_2^2) \qquad \textbf{---- (5)}$$

Now,

$I_2 - I_1 = I_0 + 2\text{i} + 2\text{m}\, d_2^2 - I_0 - 2\text{i} - 2\text{m}\, d_1^2 = 2\text{m}(d_2^2 - d_1^2)$

Subtracting (4) from (5), We have

$$T_2^2 - T_1^2 = \frac{4\pi^2}{C} [I_0 + 2\text{i} + 2\text{m}\, d_2^2 - I_0 - 2\text{i} - 2\text{m}\, d_1^2]$$

$$= \frac{4\pi^2}{C} 2\text{m}(d_2^2 - d_1^2)$$

$$= \frac{4\pi^2}{C} (I_2 - I_1) \qquad \text{----- (6)}$$

Dividing eqn.(1) by eqn.(6)

$$\frac{T_0^2}{T_2^2 - T_1^2} = \frac{I_0}{I_2 - I_1} \text{---- (7)}$$

Substituting the value of (I_2-I_1) in this equation (7), we have

$$\frac{T_0^2}{T_2^2 - T_1^2} = \frac{I_0}{2m(d_2^2 - d_1^2)}$$

$$\boldsymbol{I_0 = \frac{2m(d_2^2 - d_1^2)}{T_2^2 - T_1^2} T_0^2}$$

Calculation of rigidity modulus of the wire

We know that restoring couple per unit twist

$$C = \frac{\pi n r^4}{2l} \text{-----(8)}$$

Substituting the value of C in expression (6) we have

$$T_2^2 - T_1^2 = \frac{4\pi^2}{\frac{\pi n r^4}{2l}} 2m(d_2^2 - d_1^2)$$

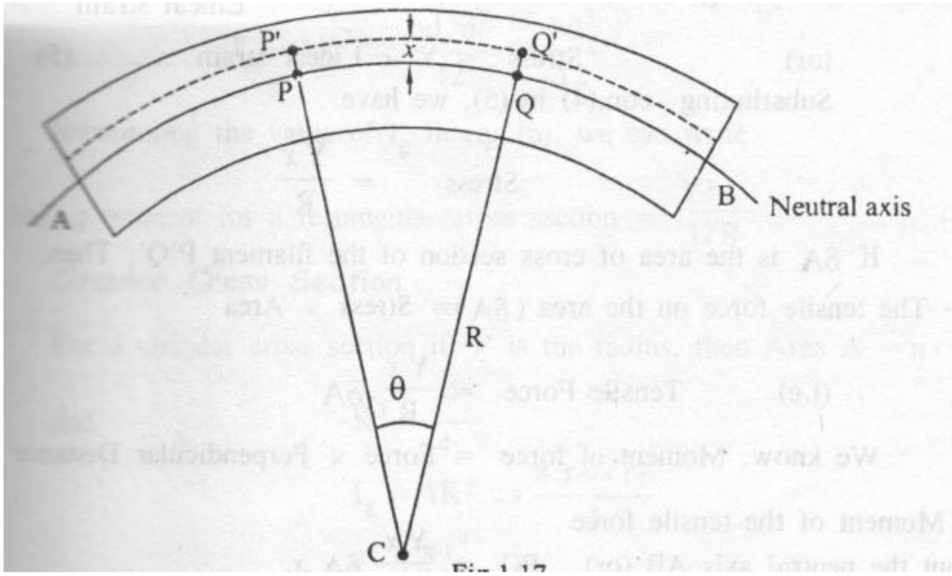
$$= \frac{4\pi^2}{\pi n r^4} \; 2l \times 2m(d_2^2 - d_1^2)$$

$$= \frac{16\pi m l(d_2^2 - d_1^2)}{n r^4}$$

$$\boldsymbol{n = \frac{16\pi m l(d_2^2 - d_1^2)}{(T_2^2 - T_1^2) r^4}} \text{---- (9)}$$

4. Derive an expression for bending of a beam.

Let us consider a beam under the action of deforming forces. The beam bends into a circular arc. Let AB are elongated and the filaments below AB are compressed. The filament AB remains unchanged.



Let PQ be the arc chosen from the neutral axis. If R is the radius of curvature of the neutral axis and θ is the angle suspended by it as its centre of curvature C.

Original length PQ=Rθ ---------------------------1

P'Q' at a distance 'x' from the neutral axis.

We can write the extended length =P'Q' = (R+x)θ ----------------2

From eqn. 1 and 2 we have,

Increase in length = P'Q' – PQ

= (R+x)θ - Rθ = xθ --------------------3

Linear strain = $\frac{increase\ in\ length}{Original\ length} = \frac{x\theta}{R\theta} = \frac{x}{R}$ ------------------4

Youngs modulus Y= – $\frac{stress}{liner\ strain}$

Stress = Yx linear strain ------------------------ 5

Stress = $\frac{Yx}{R}$

If δA is the area of cross section of the filament P'Q'.

Tensile force on the area δA = stress x area

Tensile force = $\frac{Yx}{R}$ δA

Moment of force = Force x perpendicular distance

Moment of force about the neutral axis AB OR PQ = $\frac{Yx}{R}\delta A.\ x$

PQ = $\frac{Y}{R}\delta A.\ x^2$

The moment of force acting on both the upper and lower halves of the neutral axis can be got by summing of tensile and compressive forces about the neutral axis.

The moment of all the forces about neutral axis = $\frac{Y}{R}\Sigma x^2\delta A$.

$I_g = \Sigma x^2\delta A = AK^2$ is called as the geometrical moment of inertia.

Where, A is the total area of the beam, K is the radius of gyration.

Total moment of all the forces or internal bending = $\frac{YI_g}{R}$

Case i. Rectangular cross-section

If b is the breadth and d is the thickness of the beam,

Area A = bd

$$K^2 = \frac{d^2}{12}$$

$$\therefore I_g = AK^2 = \frac{bd.d^2}{12} = \frac{bd^3}{12}$$

Substituting value of I_g in eqn. 6 , We can write

Bending moment for a rectangular cross section = $\frac{Ybd^3}{12R}$ --------------------7

Case ii.Circular cross-section

If r is the radius of rod, A = πr^2

$$K^2 = \frac{r^2}{4}$$

$$\therefore I_g = AK^2 = \frac{\pi.r^2.r^2}{4} = \frac{\pi r^4}{4}$$

Substituting value of I_g in eqn. 6 , We can write

Bending moment for a circular cross section = $\frac{\pi Yr^4}{4R}$ --------------------8

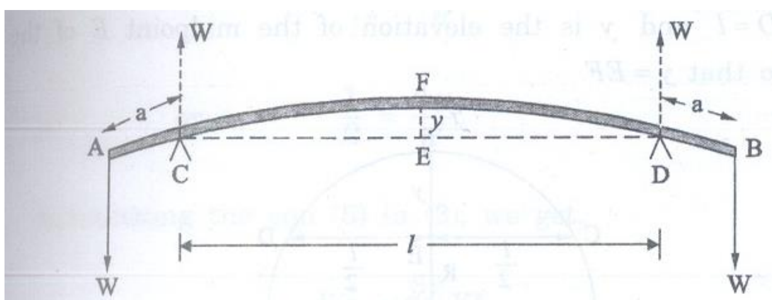
5. What is uniform bending? Derive an expression for the elevation at the centre of a beam which is loaded at the both ends. Describe an experiment to determine Young's modulus of a beam by uniform bending.

Definition:

- If the beam is loaded uniformly on its both ends, bending of the beam forms an arc of a circle. The elevation is produced in the beam. This type of bending is known as uniform bending.

Theory:

- Consider a beam AB arranged horizontally on two knife- edges C and D symmetrically.
- The beam is loaded with equal weights W at each ends A and B.
- The reaction on the knife edges at C and D are equal to W and they are acting vertically upward.



External bending moment on the part AF

$$= W \times AF - W \times CF$$

$$= W(AF - CF) = W \times AC$$

$$= W a \qquad \text{------(1)}$$

Internal bending moment= $\frac{YI}{R}$ -------(2)

Y – Young's modulus of the beam

I - Geometrical moment of inertia

R – Radius of curvature of the beam

In the equilibrium position,

External bending moment = Internal bending moment

$$Wa = \frac{YI}{R} \text{-------}(3)$$

Then,from the property of a circle

$$EF \times EG = CE \times ED$$

$$Y\,(2R - y) = \left(\frac{l}{2}\right)^2$$

$$2yR - y^2 = \frac{l^2}{2^2} = \frac{l^2}{4}$$

$$y2R = \frac{l^2}{4} (y^2 \text{ -- is negligible})$$

$$y = \frac{l^2}{8R}$$

$$\frac{1}{R} = \frac{8y}{l^2} \text{-----------}(5)$$

Substituting the eqn (5) in (3), we have

$$Wa = \frac{8y}{l^2}\, YI$$

$$Y = \frac{Wal^2}{8Iy} \text{---------}(6)$$

If the beam is rectangular section ,

$$I = \frac{bd^3}{12}$$

The corresponding weight ,

$$W = Mg$$

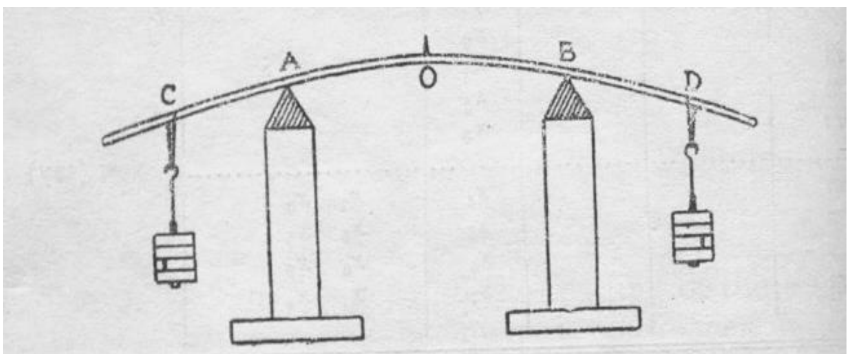
Substituting for W and I in egn (6) , we have

$$Y = \frac{Mgal^2}{8\frac{bd^3}{12}\,y}$$

$$\mathbf{Y} = \frac{3}{2}\frac{Mgal^2}{bd^3y}$$

Experiment

- A rectangular beam AB of uniform - section is supported horizontally on two knife-edges A and B.
- Two weight hangers of equal masses are suspended from the ends of the beam. A pin is fixed vertically at the mid-point of the beam. A microscope is focused on the tip of the pin.



- Initial reading in the microscope in the vertical scale is noted. Equal weights are added to both hangers simultaneously and the reading in the microscope on the vertical scale is noted.

- The experiment is repeated for decreasing order of the equal masses.
- The observations are tabulated and mean elevation (y) at the midpoint of the bar is determined.

- The length of the bar between the knife edges 'l' is measured. The distance of the one of the weight hangers from the nearest knife edge 'a' is measured.

- The breadth (b) and thickness (d) of the bar are measured by using vernier calipers and screw gauge.

Load (gm)	Microscope Readings							Depression (y)
	Loading			Un – loading			Mean (cm)	
	cm							
W								
W+50								
W+100								
W+150								
W+200								
W+250								
							Mean	

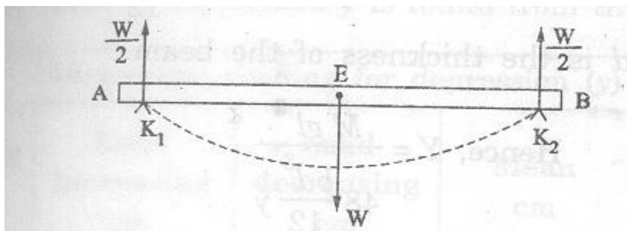
➢ Young's modulus of the beam is determined by the relation.

$$\mathbf{Y} = \frac{3}{2}\frac{Mgal^2}{bd^3y}$$

6. **Describe with necessary theory , the method of determining the Young's modulus of the material of the beam if rectangular cross-section by bending it non-uniformly.**

NON - UNIFORM BENDING

- **If the beam is loaded at its mid-point, the depression produced does not form an arc of a circle. This type of bending is called non-uniform bending.**
- Consider a uniform cross sectional beam (rod or bar) AB of length l arranged horizontally on two knife edges K_1 and K_2near the ends A and B.



- A weight W is applied at the midpoint 'O' of the beam. The reaction force at each knife edge is equal to $\frac{W}{2}$ in the upward direction. y is the depression at the mid point O.

- The bent beam is considered to be equivalent to two inverted cantilevers, fixed at O each of Length $\frac{l}{2}$ and each loaded at K_1 and K_2 with a weight $\frac{W}{2}$

In the case of a cantilever of length l and load W, the depression = $\frac{Wl^3}{3Iy}$

Hence, for cantilever of length $\frac{l}{2}$and load $\frac{W}{2}$depression is

$$y = \frac{\left(\frac{W}{2}\right)\left(\frac{l}{2}\right)^3}{3Iy}$$

$$y = \frac{Wl^3}{48IY}$$

If M is the mass, the corresponding weight W is

$$W = Mg$$

If the beam is a rectangular, $I = \frac{bd^3}{12}$ where b is the breadth and d is the thickness of the beam.

Hence, $$Y = \frac{Mgl^3}{48\frac{bd^3y}{12}}$$

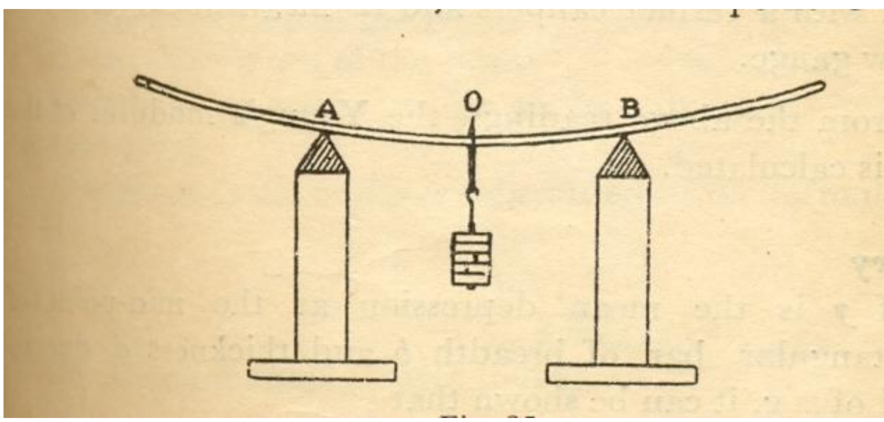
$$= \frac{12\,Mgl^3}{48\,bd^3y}$$

$$\mathbf{Y = \frac{Mgl^3}{4\,bd^3y}}$$

The value of Y can be determined by the above equation.

Experiment

- The given beam AB of rectangular cross section is arranged horizontally on two knife edges K_1 and K_2 near the ends A and B.



- A weight hanger is suspended and a pin is fixed vertically at mid-point O.
- A microscope is focussed on the tip of the pin.

- The initial reading on the vertical scale of the microscope is taken. A suitable mass M is added to the hanger. The beam is depressed. The cross wire is adjusted to coincide with the tip of the pin. The reading of the microscope is noted.
- The depression corresponding to the mass M is found.
- The experiment is repeated by increasing and decreasing the mass step by step. The corresponding readings are tabulated. The average value of depression y is found from the observation

➢ The breadth b, thickness d and length L of the beam are measured.

Load (gm)	Microscope Readings							Depression (y)
	Loading			Un – loading			Mean (cm)	
	cm							
W								
W+50								
W+100								
W+150								
W+200								
W+250								
							Mean	

➢ The value of Young's modules of the beam is found by the relation.

$$Y = \frac{Mgl^3}{4\,bd^3y}$$

Appendix

What is cantilever? Derive an expression for depression at the free end of cantilever.

CANTILEVER

- cantilever is a beam fixed horizontally at one end and loaded at the other end

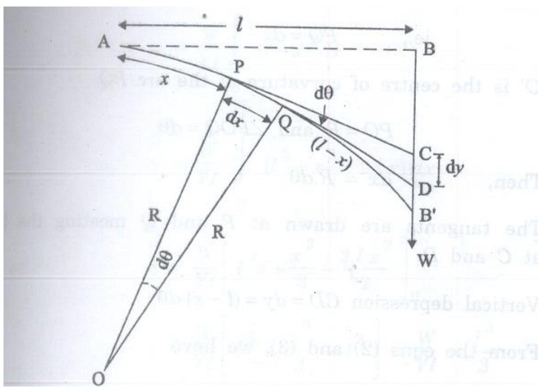
  Under equilibrium condition,

- External bending moment = Internal bending moment

DEPRESSION OF A CANTILEVER-LOADED AT ITS ENDS
THEORY:

- Consider a cantilever of length l fixed at the end A and loaded at the free end B by a weight W. The end B depressed to B^1. AB is the neutral axis.

- Consider the section of the cantilever P at a distance x from the fixed end A. It is at distance (l-x) from the loaded end B^1.



The external bending moment $=W(l-x)$

The internal bending moment $= \frac{YI}{R}$

Under Equilibriumcondition,

External bending moment = Internal bending moment Therefore,

$$W\,(l\text{-}x) = \frac{YI}{R} \text{ --------------- } (1)$$

Q is the another point at a distance dx from P

$$PQ = dx = R\,d\theta \qquad \text{----------- } (2)$$

Vertical depression ,

$$dy = (l\text{-}x)\,d\theta \qquad \text{--------------}(3)$$

From the eqns (2) and (3) ,we have

$$\frac{dy}{dx} = \frac{R\,d\theta}{(l-x)d\theta} = \frac{R}{(l-x)}$$

$$R = \frac{(l-x)dx}{dy} \qquad \text{-----------------}(4)$$

Substituting for R in eqn (1) ,we have

$$W\,(l\text{-}x) = \frac{YI\,dy}{(l-x)dx} \qquad \text{------------------ } (5)$$

Rearranging eqn (5) ,we have

$$dy = \frac{W}{YI}(l-x)\,(l-x)\,dx$$

$$dy = \frac{W}{YI}\,(l\text{-}x)^2\,dx \qquad \text{-------------}(6)$$

Total deperssion y at the free end is

$$\int dy = \int_0^l \frac{W}{YI}\,(l\text{-}x)^2\,dx \text{ ------------}(7)$$

$$y = \frac{W}{YI}\int_0^l (l-x)^2\,dx$$

$$y = \frac{W}{YI}\int_0^l (l^2 + x^2 - 2lx) \, dx$$

$$y = \frac{W}{YI}\left[l^2x + \frac{x^3}{3} - \frac{2lx^2}{2}\right] dx$$

$$y = \frac{W}{YI}\left[l^3 + \frac{l^3}{3} - l^3\right] dx$$

$$y = \frac{W}{YI} \text{x} \frac{l^3}{3}$$

$$\mathbf{y} = \boldsymbol{\frac{Wl^3}{3YI}} \quad \text{------------}(8)$$

Determination of Young's modulus of the cantilever

Depression for the free end of the cantilever

$$\mathbf{y} = \boldsymbol{\frac{Wl^3}{3YI}}$$

Young's modulus of the cantilever

$$\mathbf{Y} = \boldsymbol{\frac{Wl^3}{3Iy}} \text{--------------}\mathbf{(9)}$$

For a beam of rectangular cross-section ,

$$I = \frac{bd^3}{12}$$

Where b is the breadth and d thickness of the beam.

The weight W = Mg

Where M is the mass suspended at the free end and g is acceleration due to gravity.

Substituting for W and I in egn (9) , we have

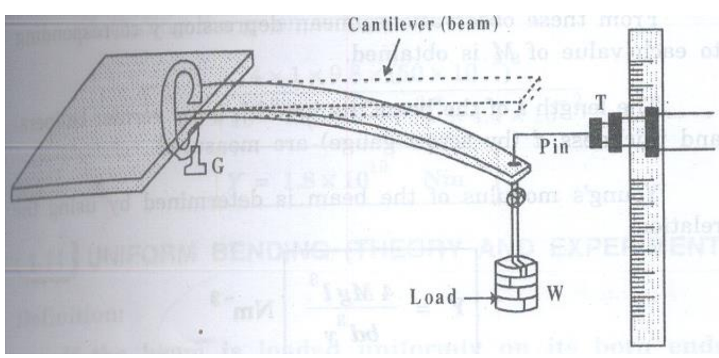
$$Y = \frac{Mgl^3}{3\frac{bd^3 y}{12}}$$

$$= \frac{Mgl^3}{\frac{bd^3\, y}{4}}$$

$$\mathbf{Y = \frac{4Mgl^3}{bd^3\ y}}$$

Experimental determination of young s modulus of a cantilever:

- The given bar is fixed rigidly at one end and a weight hanger is suspended at the other end.
- A pin is fixed vertically at the free end of the beam. A travelling microscope is focused on the pin. The microscope is adjusted such that the horizondal cross-wire coincides with the tip of the pin.The initial reading in the microscope on the vertical is noted.
- A suitable mass M is placed on the hanger. The reading in the microscope is again noted. The difference between two readings of the microscope gives the depression y corresponding to load M.



- ➢ The experiment is repeated by increasing the values of M in the steps of 50 gm. Then, the experiment is also repeated by decreasing the weights.

- ➢ The length l of the beam, its breadth b and thickness d are measured.

Load (gm)	Microscope Readings							Depression (y)
	Loading			Un – loading			Mean (cm)	
	cm							
W								
W+50								
W+100								
W+150								
W+200								
W+250								
							Mean	

- ➢ Young's modulus of the beam is determined by the relation.

$$\mathbf{Y} = \frac{4Mgl^3}{bd^3y}$$

UNIT- II

①

Sound & Ultrasonics

classification of Sound.

Sound

- frequency below 20 HZ — Infrasonics
- Audible range of frequency 20-20000 HZ
  - Music
  - noise
- Frequency above 20,000 HZ — Ultrasonics

Characteristics of musical sound

(i) **pitch**: It is the characteristic of sound which is the sensation conveyed to our brain by the sound waves falling in our ears. It depends on the frequency of incident sound waves.

frequency - physical Quantity, Pitch - physiological Quantity

(ii) **Quality** or Timbre

This helps us to distinguish between musical notes emitted by different musical instruments or voices, eventhough they have the same pitch and loudness.

(iii) **Intensity** or Loudness:

The average rate of flow of accoustic energy (Q) per unit area situated normally to the direction of propagation of sound wave.

$$I = Q/A$$

$$I \propto \frac{n^2 a^2 \rho V}{x^2}$$

$n \rightarrow$ frequency of sound

$a \rightarrow$ amplitude of "

$\rho \rightarrow$ density of the medium

$V \rightarrow$ velocity of sound in "

$x \rightarrow$ distance from source to destination

Intensity/unit area/unit time

$$I = 2\pi^2 a^2 n^2 \rho V$$

Loudness

It is defined as the degree of sensation produced on the ear. Loudness varies from one observer to another. It is a physiological quantity and it is difficult to measure loudness.

Logarithmic value of intensity $L \propto \log I$

$L = k \log I \longrightarrow ①$

weber fechner law

Differentiating eqn ①

$$\frac{dL}{dI} = \frac{k}{I}$$

$\frac{dL}{dI}$ is sensitiveness of ear.

↳ decreases with the increase in intensity

Intensity	Loudness
→ Refers to external measurement	→ Just a sensation produced on the ear.
→ It is common to hear sound produced	→ It depends on individual listener.
→ It can be measured directly	→ measured with respect to intensity.

Units of Loudness

If L_1 is the Loudness of sound of Intensity I_1 and L_0 is the Loudness Corresponding to the standard reference intensity $I_0 = 10^{-12} W/m^2$

Apply weber-fechner Law,

$$L_1 = k \log_{10} I_1$$

$$L_0 = k \log_{10} I_0$$

If $I_L = L_1 - L_0 = k \log_{10} I_1 - k \log_{10} I_0$

$$I_L = k \log_{10} \frac{I_1}{I_0}$$

If $k = 1$

$$I_L = 1 \times \log_{10} \frac{I_1}{I_0} \text{ bel}$$

bel - unit named after Alexander GrahamBell.

Decibel

The unit 'bel' is quite Large and hence I_L is expressed by another Standard unit called decibel

$$1 \text{ Bel} = 10 \text{ decibels}$$

$$I_L = 10 \log_{10} \frac{I_1}{I_0} \text{ dB} \rightarrow (1)$$

If $I_L = 0$ dB, $\log_{10} \frac{I_1}{I_0} = 0$; $\frac{I_1}{I_0} = 10^0$

$$\frac{I_1}{I_0} = 1 \rightarrow (2)$$

If $I_L = 1$ dB

$$\log_{10} \frac{I_1}{I_0} = \frac{1}{10} \quad ; \quad \frac{I_1}{I_0} = (10)^{1/10}$$

$$\left(\frac{I_1}{I_0}\right) = 1.26. \quad \rightarrow (3)$$

(3) − (1)

$1.26 - 1 = 0.26$

Threshold of hearing	Intensity level (dB)
	0
Rustle of Leaves	10
Whisper	15 – 20
Average house	40
Ordinary conversation	60 – 65
Motors or heavy traffic	70 – 80
Roaring of lion at 20 feet	90
Thunder	100 – 110
painful Sound	120 <

Reverberation:

When a Sound pulse is produced in a hall, the Sound wave travels towards all direction and are reflected back by the walls, floors, doors, windows, Ceiling etc. There are many reflections, before it becomes inaudible.

"The existence (or) prolongation (or) persistance of Sound in the hall even after the source of Sound is stopped is called Reverberation."

Reverberation time

The time taken for the sound to fall below the minimum audibility measured from the instant when the source stopped sounding.

Sabine formula

$$T = \frac{0.167\,V}{\Sigma\, as}$$

V - volume of Hall

s - Surface area

a - absorption coefficient of the materials kept inside the hall.

Factors affecting the Acoustics of Buildings

During the sound propagation, there is a possibility for causing interference between those waves which intern affects the originality of the sound produced.

1. unoptimised reverberation time
2. Very low or very high loudness
3. Improper focusing of sound to a particular area which may cause interference.
4. Echoes or Echelon effects produced inside the buildings.
5. Resonance caused due to matching of sound waves.
6. Unwanted sound from outside or inside the buildings, so called noise may also effect the acoustics of builings

Focussing

Accumulation of soundwaves on direction of propagation of soundwaves only in particular direction is known as focus. Due this focus, the uniformity of sound distribution inside a hall will not be equal.

Interference

Two or more soundwaves may meet eachother during its propagation is called interference. This interference of sound will change the original quality of sound.

Echoes & Echelon Effect.

In some halls, the walls of the halls will scatter the sound waves rather than reflecting it, this may create nuisance effect due to echoes.

The echoes are formed when the time interval between the direct and reflected sound waves are about $1/15^{th}$ of a second. This effect occurs due to the reason that the reflected sound waves reaches the observer later than the direct sound.

If there is a regular repetition of echoes of the original sound to the observer then the effect is called as Echelon effect.

Echo can be avoided by lining the surfaces with suitable sound absorbing materials

Resonance

Resonance occurs when a new sound note of frequency matches with standard audio frequency. Sometimes the window panel, sections of wooden portion are thrown into vibrations to produce new sounds, which results interference between original sound and created sound.

→ It can be avoided by providing proper ventilation and by adjusting the reverberation time

→ Air conditioning is completely eliminating the resonance

Noise:

Noise is an unwanted sound produced due to heavy traffic outside the hall which leads to displeasing effect on the ear.

There are three types in noise

i) Airborne noise
ii) Structure borne noise
iii) Inside noise

Airborne noise:

The noise which reaches the hall through open windows, doors and ventilations are called as air borne noise.

Structure borne noise:

The noise that reaches the hall through the structures of the buildings are termed as structure borne noise.

Inside noise:

The noise that are produced inside the halls is known as inside noise.

factors to be followed for Good Acoustics of Buildings

(i) The reverberation time should have an optimum level.

(ii) The sound must be evenly distributed to each and every part of the building

(iii) There should not be any focussing of sound to any particular area.

(iv) Each and every note of sound must be heard Clearly and distinctly without any interference

(v) echoes, echelon effect and resonance inside the buildings should be eliminated

(vi) building should be a sound proof building

(vii) Quality of sound to be served to all audiences equally.

Ultrasonics

1 . Define Ultrasonic waves?

The sound waves having frequencies above the human audible range are known as ultrasonic waves. i.e . Above 20KHz or 20000Hz.

2. Name the methods for the production of ultrasonic waves?

1. Mechanical generators or Galton – Whistle method
2. Magnetostriction method
3. Piezo electric method

3. Mention the properties of ultrasonic waves?

1. Ultrasonic waves have high sound frequency. i.e. > 20Khz.
2. It travels longer distance with no appreciable loss of energy.
3. Its velocity is constant for a homogeneous medium.
4. Like ordinary sound waves , ultrasonic waves get reflected, refracted and absorbed.
5. Ultrasonic waves produce intense heating effect when passed through a substance.

4. What is magnetostriction effect?

When a rod of ferromagnetic materials like nickel, iron, cobalt etc, is placed in an alternating magnetic field parallel to its length, an alternate expansion and contraction are occur. This effect is known as magnetostriction effect.

5. What is Piezo electric effect?

When a mechanical pressure is applied to one pair of opposite faces of certain crystals like quartz, tourmaline, Rochelle salt, etc, an equal and opposite electrical charges are developed on the other two faces of the crystal.

6. What is Inverse Piezo electric effect?

When an electric field is applied to one pair of opposite faces of a quartz crystal, expansion or contraction is developed across the other pair of opposite faces of the crystal. This is called inverse piezo electric effect.

7.Define Cavitation?

When the ultrasonic waves pass through a liquid, they produce alternate regions of rarefaction and compression in the liquid.

A negative local pressure at the spot of rarefaction causes local boiling of the liquid accompanied by the bubble growth and collapse. This is known as cavitation.

8.Explain the phenomenon of magneto striction. How will you produce high frequency sound waves with its help?

When a rod of ferromagnetic materials like nickel, iron, cobalt etc, is placed in an alternating magnetic field parallel to its length, an alternate expansion and contraction are occur. This effect is known as magnetostriction effect.

Construction:

A ferromagnetic rod is clamped at the middle between two knife edges.

Coil L_1 is wound on the right end of the rod. It is connected to a collector of

Coil L_2 is wound on the left end of the rod. It is connected to base of the transistor. This coil is used as a feedback loop.

A variable capacitor is connected with coil L_1 parallel.

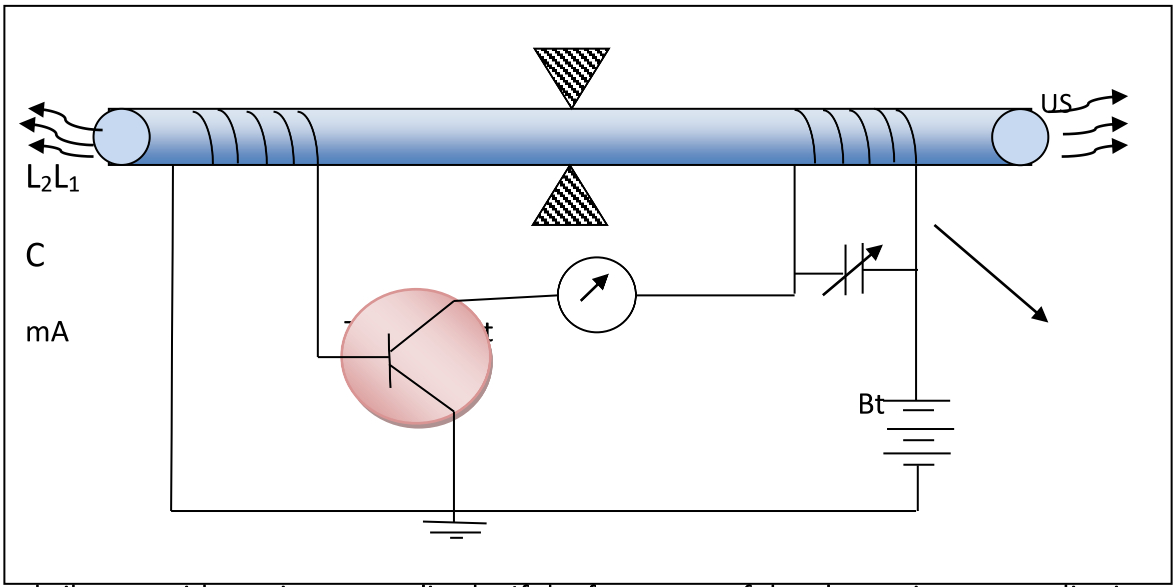
Working:

When the battery is switched on, The oscillator circuit L_1C (Tank circuit) Produces an alternating current .The frequency of L_1C is

$$f = \frac{1}{2\pi\sqrt{L_1 C}}$$

This alternating current flows through the coil L_1 and it produces an alternating magnetic field along the length of the rod. The rod begins to vibrate due to magnetostrictive effect.

The variable capacitor is adjusted to set the frequency of alternating current is equal to the natural frequency of the rod. Now the resonance condition occurs.



The rod vibrates with maximum amplitude. If the frequency of the alternating current lies in ultrasonic frequency range, then the rod produces ultrasonic waves from its both ends.

The natural frequency of vibration of the rod is

$$f_n = \frac{1}{2l}\sqrt{\frac{E}{\rho}}$$

Where L = Length of the rod.

E= young's modulus of the material of the rod

ρ = Density of the material of the rod

Condition for Resonance:

Frequency of the oscillator circuit = Frequency of the vibrating rod

$$F = \frac{I}{2\pi\sqrt{L_1C_1}} = \frac{1}{2l}\sqrt{\frac{E}{\rho}}$$

The changing magnetic flux in coil L_1 induces an e.m.f in the coil L_2 . This e.m.f is applied to the base of the transistor.

The high frequency oscillations in coil L_1 is sustained due to positive feedback.

Advantages:

- Low cost

* Simple design
* Large output

Disadvantage:

* Temperature dependent
* It has eddy current and hysteresis loss.

Describe Piezo- Electric effect method of producing ultrasonic waves?

9.What are theCutting methods in Piezo Electric Crystals

The crystals which produce piezo-electric effect and converse Piezo-electric effect are termed as Piezo-electric crystal.

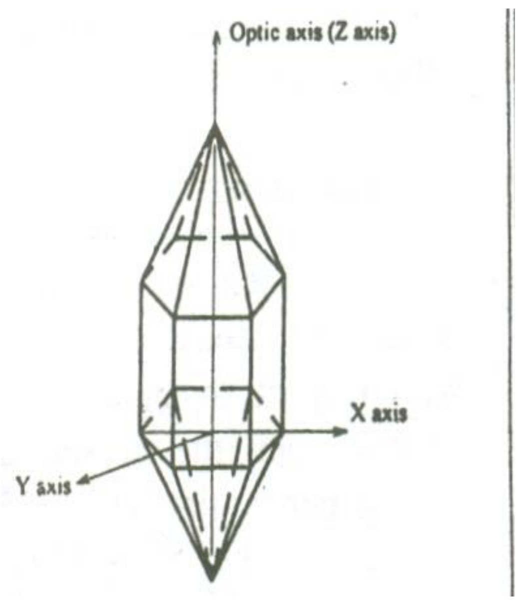
Examples: Quartz, Tourmaline, Rochelle Salts etc.

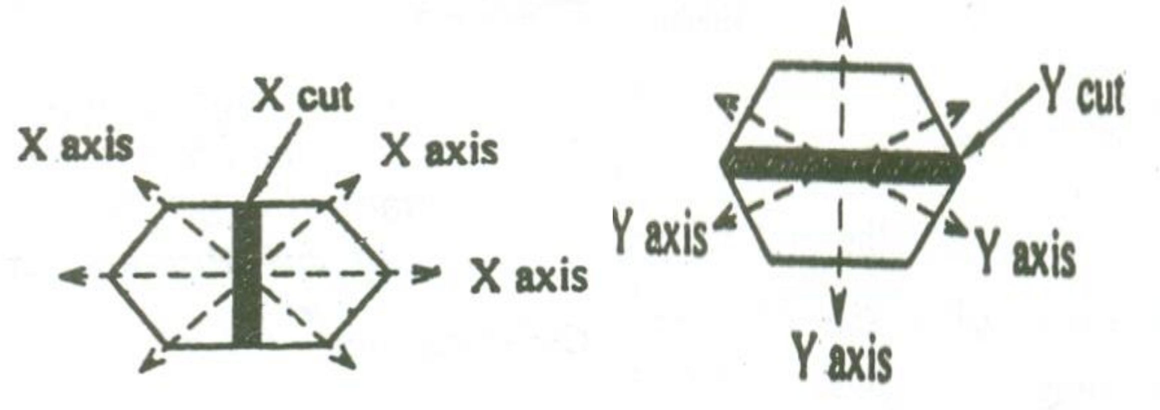
At typical example for a piezo-electric crystal (Quartz) is as shown in the figure 1.4.1. It has an hexagonal shape with pyramids attached at both ends. It consists of 3 axes . viz.,

(i) Optic Z axis, which joins the edges of the pyramid

(ii) Electrical axis(X axis), which joins the corners of the hexagon and

(iii) Mechanical axis (Y axis), which joins the center or sides of the hexagon as shown





X-cut and Y cut crystals

X - Cut crystal :

When the crystal is cut perpendicular to the X- axis, as shown in the figure 1.4.2, then it is called X – crystal.

Generally X- cut crystals are used to produce longitudinal ultrasonic waves.

Y-cut Crystal:

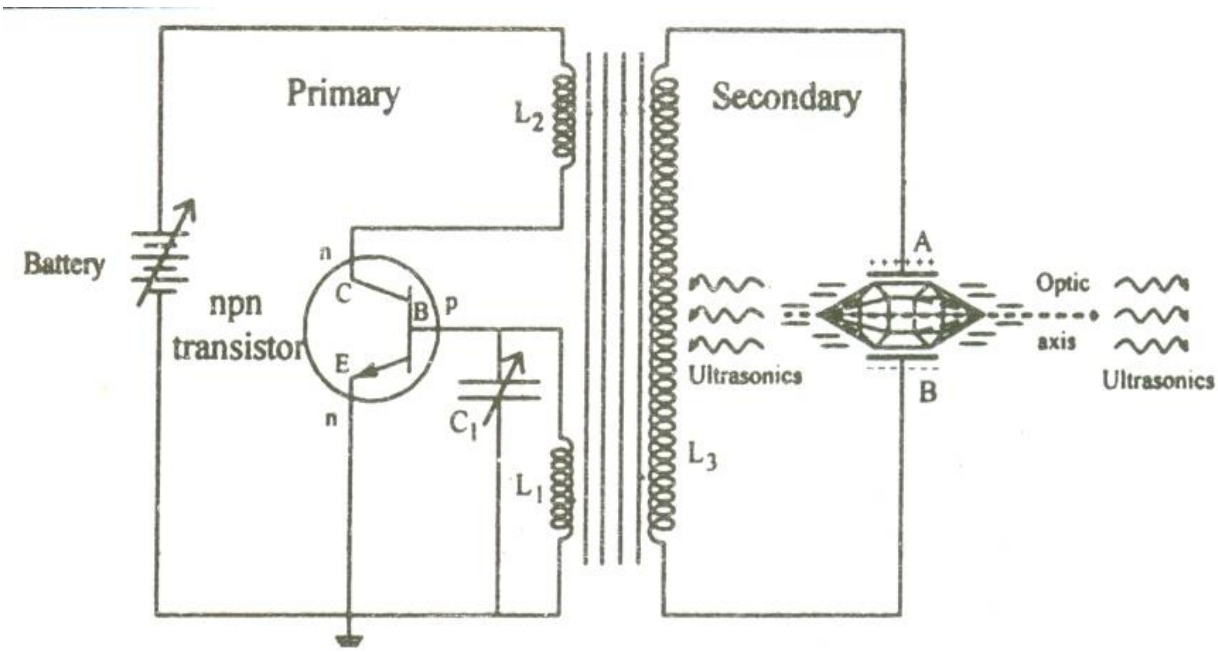
When the crystal is cut perpendicular to the Y –axis, as shown in the figure 1.4.3, then it is called Y –cut crystal.

Generally, Y –cut crystals produces transverse ultrasonic waves.

10.Describe Piezo- Electric effect method of producing ultrasonic waves?

Principle:

This is based on the ***Inverse piezoelectric effect.*** When a quartz crystal is subjected to an alternating potential difference along the electric axis, the crystal is set into elastic vibrations along its mechanical axis. If the frequency of electric oscillations coincides with the natural frequency of the crystal, the vibrations will be of large amplitude. If the frequency of the electric field is in the ultrasonic frequency range, the crystal produces ultrasonic waves.



Construction:

The circuit diagram is shown in the figure 1.5 It is base tuned oscillator circuit. A slice of Quartz crystal is placed between the metal plates A and B so as to form a parallel plate capacitor with the crystal as the dielectric. This is coupled to the electronic oscillator through the primary coil L_3 of the transformer.

Coils L_2 and L_1 of oscillator circuit are taken for the primary of the transformer. The collector coil L_2 is inductively coupled to base coil L_1. The coil L_1 and variable capacitor Cform the tank circuit of the oscillator.

Working:

When the battery is switched on, the oscillator produces high frequency oscillations. An oscillatory e.m.f is induced in the coil L_3 due to ***transformer*** action. So the crystal is now under high frequency alternating voltage.

The capacitance of C_1 is varied so that the frequency of oscillations produced is in resonance with the natural frequency of the crystal. Now the crystal vibrates with larger amplitude due to resonance. Thus high power ultrasonic waves are produced.

Condition for Resonance:

Frequency of the oscillator circuit = Frequency of the vibrating crystal

$$F = \frac{I}{2\pi\sqrt{L_1C_1}} = \frac{P}{2l}\sqrt{\frac{E}{\rho}}$$

Where 'l' is the length of the crystal

'E' is the Young's modulus of the rod

'ρ' is the density of the material of the rod

'P' = 1, 2, 3 …etc for fundamental, first overtone, second overtone etc respectively

Advantages:

1. Ultrasonic frequencies as high as 500 MHz can be generated.
2. The output power is very high. It is not affected by temperature humidity.
3. It is more efficient than the Magnetostriction oscillator.
4. The breadth of the resonance curve is very small. So we can get a stable and constant frequency of ultrasonic waves.

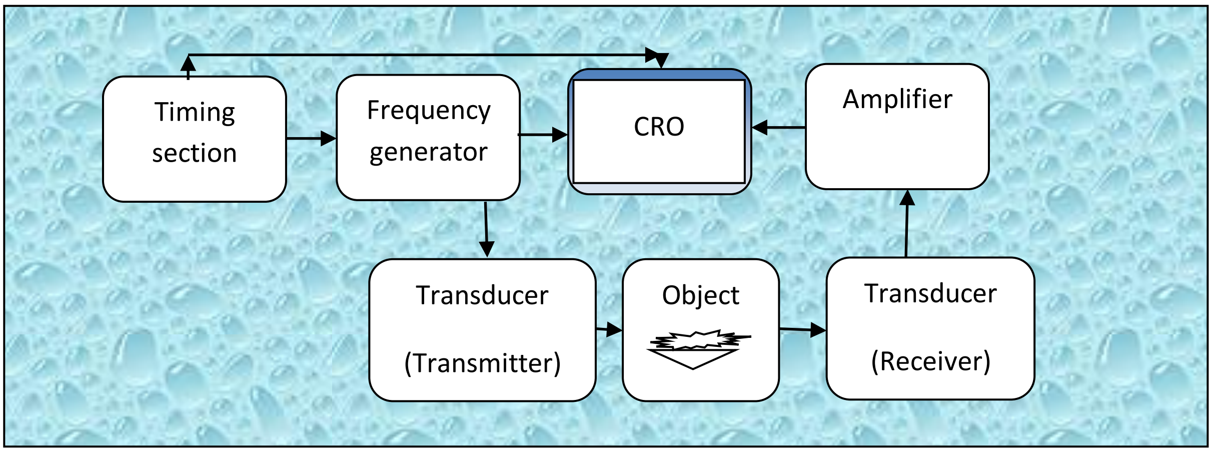
Disadvantages:

1. The cost of the quartz crystal is very high.
2. Cutting and shaping the crystal is quite complex.

Sound Navigation and Ranging (SONAR)

Principle:

It is based on the principle of Echo – Sounding. When the Ultrasonic waves are transmitted through water, it is reflected by the objects in the water and will produce an echo signal. The change in frequency of the echo signal, due to Doppler Effect helps us in determining the velocity and the direction of the object.

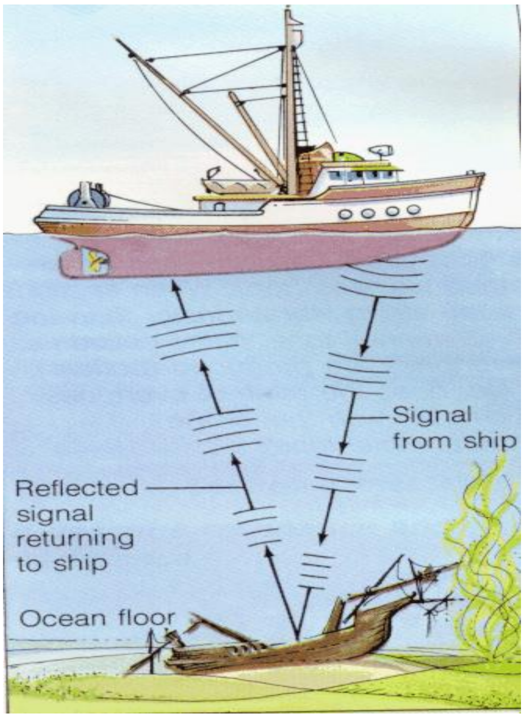


Description:

It consists of timing section which triggers the electric pulse from the pulse generator. This pulse generator is connected to the transducer so that ultrasonics can be produced. The transducer is further connected with the CRO for display. The timing section is also connected to the CRO display for reference of the timing at which the pulse is transmitted as shown in the block diagram .

Working:

- The transducer is mounted on the ship's hull without any air gap between them as shown.
- The timing at which the pulse generated is recorded at the CRO for reference .
- Electrical pulse triggers the transducer which is kept in the hull of the ship to produce ultrasonic waves due to the principle of inverse piezo-electric effect.
- These ultrasonic waves are transmitted through the water in sea.
- On striking the object the ultrasonic waves (*echo pulses*) are reflected in all directionsas shown in the figure .



Determination of Ultrasonic Velocity in Liquid

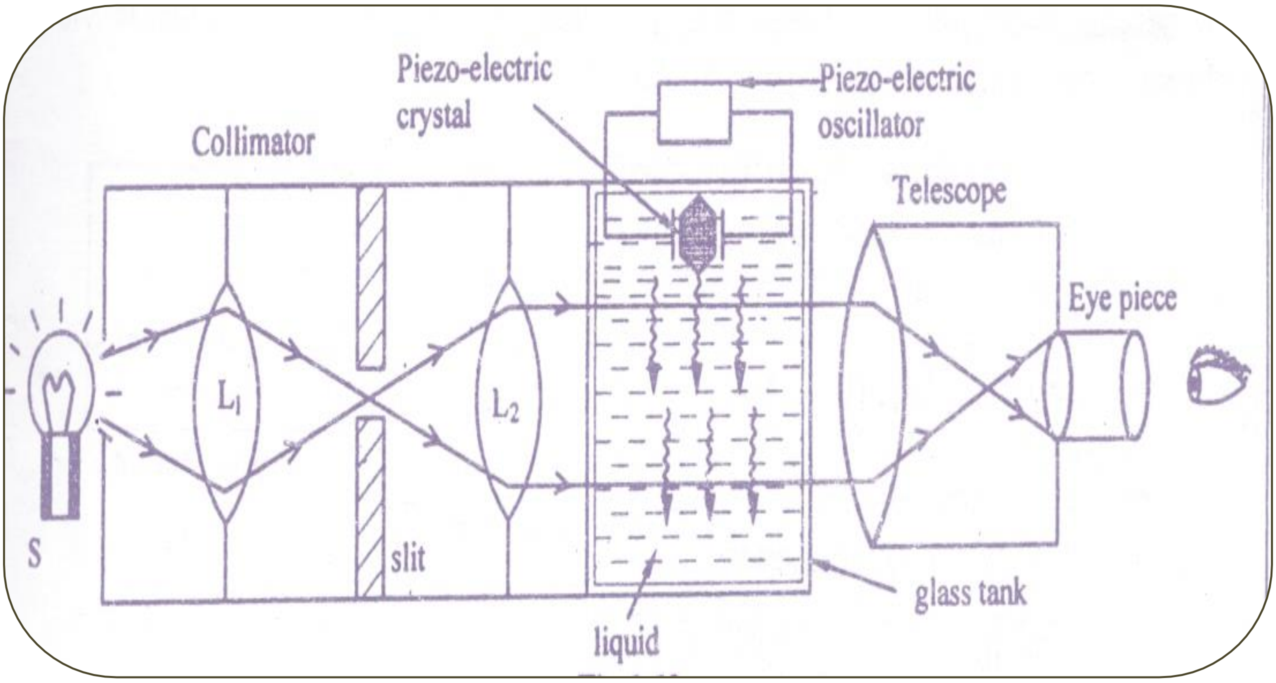
(Acoustical Grating Method)

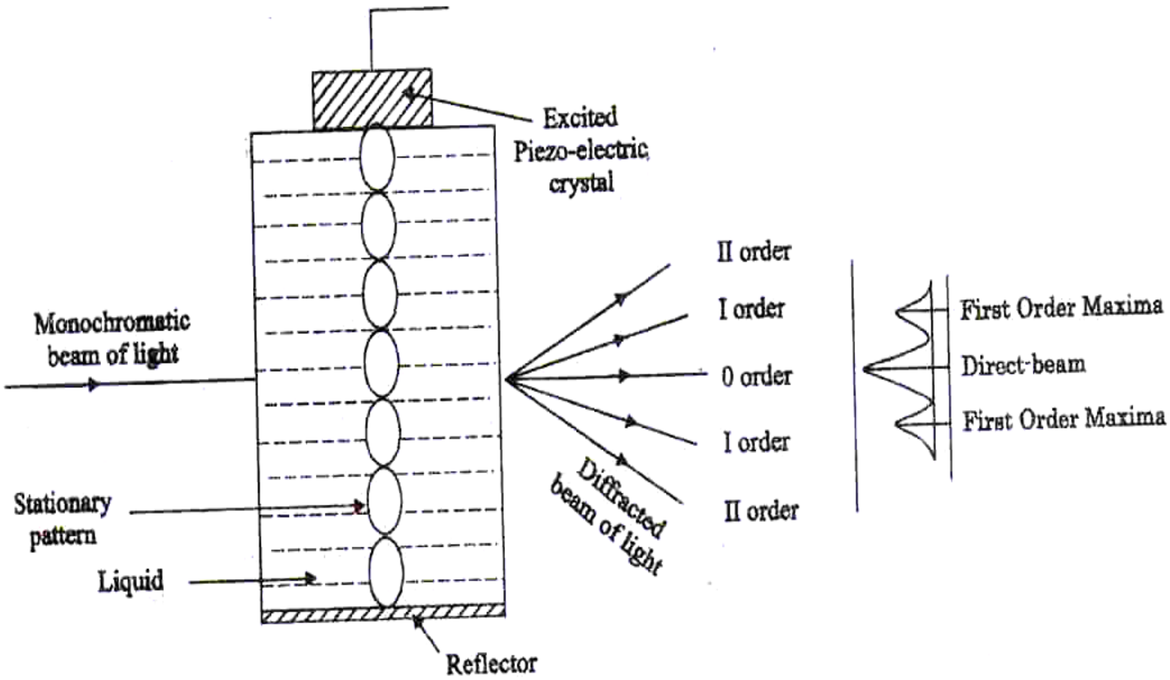
Principle:

When ultrasonic waves travel through a transparent liquid, due to alternate compression and rarefaction, longitudinal stationery waves are produced. If monochromatic light is passed through the liquid perpendicular to these waves, the liquid behaves as diffraction grating. Such a grating is known as **Acoustic Grating**. It is used to find wavelength (λ) and velocity (v) of ultrasonic waves in the liquid.

Construction:

- It consists of a glass tank, filled with the liquid.
- A piezo-electric (Quartz) is fixed at the bottom of the glass tank and is connected with piezo-electric oscillatory circuit as shown in the figure .
- An incandescent lamp is used as a monochromatic source (S) and a telescope arrangement is used to view the diffraction pattern.
- A collimator consisting of two lenses L_1 and L_2 is used to focus the light effectively in the glass tank.


Piezo-electric
crystal
Piezo-electric
oscillator
Collimator
Telescope
Eye piece
S
slit
glass tank
liquid


Excited
Piezo-electric
crystal
II order
I order
0 order
I order
II order
First Order Maxima
Direct-beam
First Order Maxima
Monochromatic
beam of light
Diffracted
beam of light
Stationary
pattern
Liquid
Reflector

Working

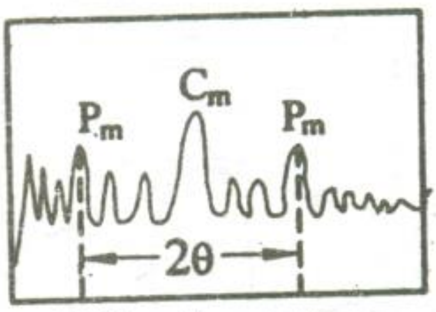
(i) When the piezo-electric crystal is kept at rest:

Initially the piezo-electric crystal is kept at rest and the monochromatic at light is switched ON. When the light is focused in the glass tank filled with the liquid, a single image, a vertical peak is observed in telescope. i.e., there is no diffraction.

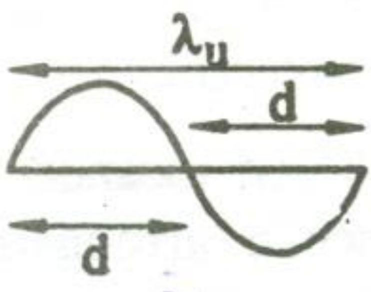
(ii) When the piezo-electric crystal is set into vibrations:

Now the crystal is put into vibrations using piezo-electric oscillatory circuit. At Resonance, Ultrasonic waves are produced and are passed through the liquid. These Ultrasonic waves are reflected by the walls of the glass tank and form a stationery wave pattern with nodes and antinodes in the liquid. *At nodes the density of the liquid becomes more and at antinodes the density of the liquid becomes less. Thus, the liquid behaves as a diffracting element called acoustical grating element.*

Now when the monochromatic light is passed the light gets diffracted and a diffraction pattern consisting of central maxima and principle maxima on either side is viewed through the telescope as shown in figure .



Diffraction pattern



Calculation of Ultrasonic Velocity

The velocity of Ultrasonic waves can be determined using the condition.

$$2d \sin\theta = n\lambda \longrightarrow (1)$$

Where, d is the distance between successive node or antinodes.

θ is the angle of diffraction

n is the order of the spectrum

λ_L is the wavelength of the monochromatic source of the light.

If $\lambda_u = 2d$ ⟶ (2)

Then, equation (1) becomes,

$$\lambda_u \sin\theta = n\lambda$$

Wavelength of Ultrasonic = $\lambda_u = \dfrac{n\lambda}{\sin\theta}$ ⟶ (3)

We know, Ultrasonic Velocity = Frequency of Ultrasonic $\times$ Wavelength of ultrasonic

Velocity of Ultrasonic $\boxed{v = \lambda_u \times \nu_u \quad (4)}$

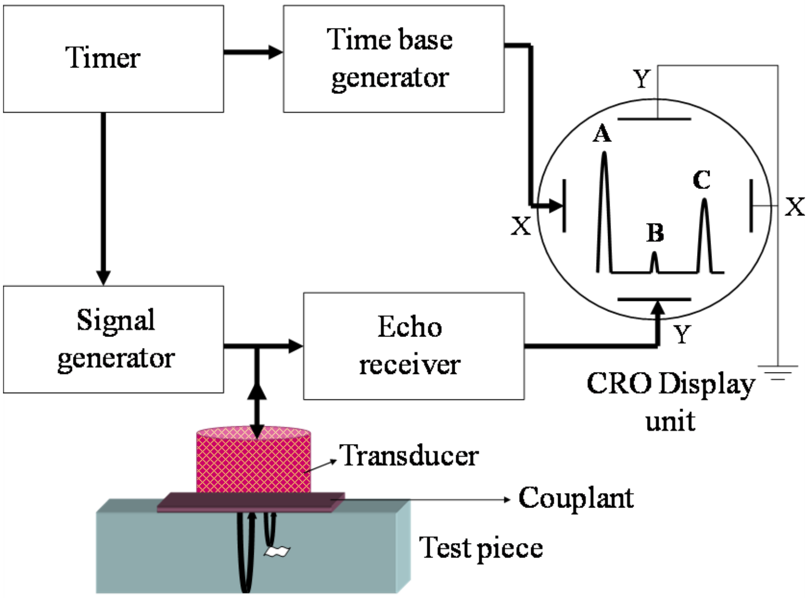
Substituting equation (3) in (4), we get

Velocity of Ultrasonic wave $v = \dfrac{\nu_u n\lambda}{\sin\theta}$

Thus, this method is useful in measuring the wavelength and velocity of ultrasonic waves in liquids, and gases at various temperatures.

Ultrasonic Non- destructive Testing (NDT)

Principle:*The basic principle behind the ultrasonic inspection is the transmission of the Ultrasound with the medium and the reflection or scattering at any surface or internal discontinuity in the medium due to the change in the acoustic impedance*. The Discontinuity means the existence of the flaw or defect or cracks or hole in the material. *The reflected or scattered sound waves are received and amplified and hence, the defects in the specimen are suitably characterized.*



Block diagram of the Ultrasonic Flaw detector

Principle:

Whenever there is a change in the medium, then the Ultrasonic waves will be reflected. This is the principle used in Ultrasonic flaw detector. Thus, from the intensity of the reflected echoes, the flaws are detected without destroying the material and hence this method is known as a Non –Destructive method.

Working:

- ♣ The pulse generator generates high frequency waves and is applied to the Piezo-electric transducer and the same is recorded in the CRO.
- ♣ The piezo-electric crystals are resonated to produce Ultrasonic waves.
- ♣ These Ultrasonic waves are transmitted through the given specimen.
- ♣ These waves travel through the specimen and is reflected back by the other end.
- ♣ The reflected Ultrasonic are received by the transducer and is converted into electric signals. These reflected signals are amplified and is recorded in the CRO.
- ♣ If the reflected pulse is same as that of the transmitted pulse, then it indicates that there is no defect in the specimen.
- ♣ On the other hand, if there is any defect on the specimen like a small hole or pores, then the Ultrasonic will be reflected by the holes (i.e.) defects due to change in the medium.

- ♣ From the time delay between the transmitted and received pulses, the position of the hole can be found.
- ♣ From the height of the pulse received the depth of the hole can also be determined.

ULTRASONIC SCANNING METHODS- A, B AND C SCAN DISPLAYS

In the Ultrasonic scanning methods, the principle, construction and working is the same as that of the Ultrasonic flaw detector. Here, it is based on the position of the transducer and the output displayed in the CRO screen, we can classify the scanning methods into three types

a. **A-scan**

b. **B-scan**

c. **T-M – scan or C-scan**

All these three modes of scanning are obtained with respect to the pulses of Ultrasound transmitted into and received from the specimen. The three modes are explained below.

a. A-Scan or Amplitude mode display

- It is the most common display mode
- The received echo pulse amplitude is plotted as displacement along Y – axis
- The travel time of the ultrasonic pulse (pulse transit time) is plotted as displacement along X – axis.
- The thickness (d) of the test piece can be calculated as, $d = \frac{vt}{2}$
- Where, *t'-time interval between the initial (A) and backwall pulse (C)*

  v- velocity of the ultrasonic waves in the medium.
- Larger the thickness (*d*), greater is the time taken for the ultrasonic pulses to travel
- Therefore, from the time interval of the flaw pulse, the location of the flaw inside the specimen can be estimated.

The A-scan presentation displays the amount of received ultrasonic energy as a function of time.

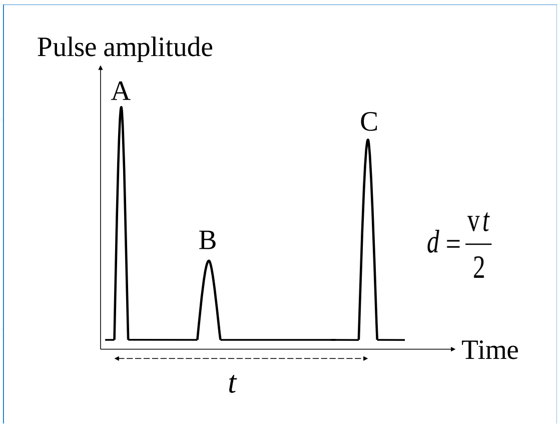
***IP* ,**Initial pulse generated by the transduceris represented by the signal

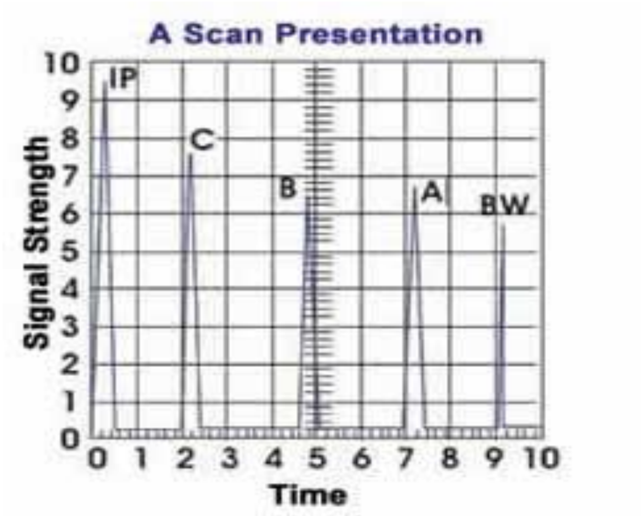
***A* ,** thesound energy reflecting from surface

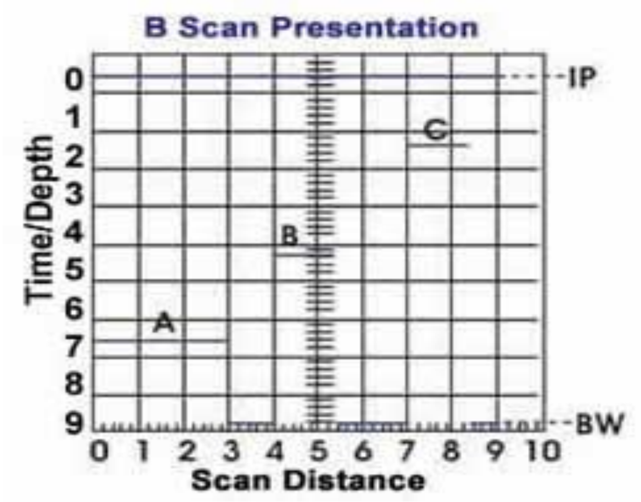
***BW* ,** a signal from the back-wall

B,flaw - I (halfway between the frontand back surfaces of the sample)

C, *flow - II*



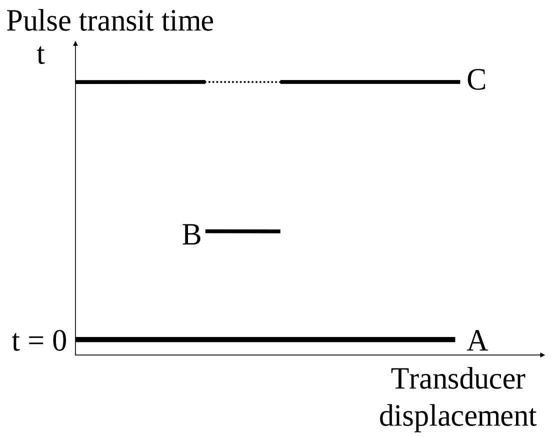




b. B-Scan or Brightness Mode Scan

In the B-scan, the time-of-flight (travel time) of the sound energy is displayed along the vertical and the linear position of the transducer is displayed along the horizontal axis.

- It gives two dimension display
- Here the transducer can be moved.
- As a result the echo's are displayed as in the figure
- Brightness & size of the dot – intensity and strength of reflected echo pulse
- It provides information about internal structures



In the figure,

A indicates the initial pulse

B is the flaw pulse

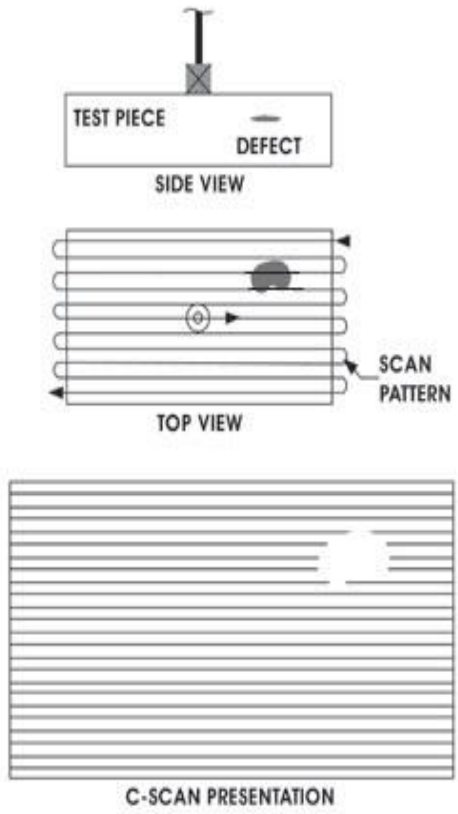
C is due to back wall reflection

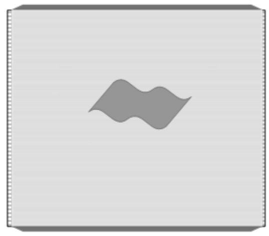
The depth of the flaw from the surface is a measure of pulse transit time

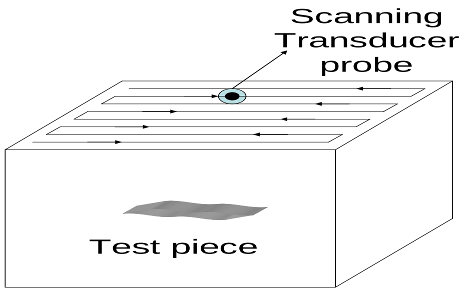
c. T.M Scan or Time – Motion Mode or C-Scan display

In a C-Scan,

- ➢ The transducer probe is scanned over the surface of the test piece
- ➢ A display memory stores the echo amplitudes corresponding to various positions of the scan surface
- ➢ The stored information are regenerated on CRT screen
- ➢ Any plane at a given depth can be imaged on the screen







- Mapping of defects in a 2D graphical representation from top view of the test surface is displayed
- The C-scan presentation provides a plan-type view of the location and size of test specimen features.
- The plane of the image is parallel to the scan pattern of the transducer.
- C-scan presentations are produced with an automated data acquisition system, such as a computer controlled immersion scanning system.
- Typically, a data collection gate is established on the A-scan and the amplitude or the time-of-flight of the signal is recorded at regular intervals as the transducer is scanned over the test piece.

- The relative signal amplitude or the time-of-flight is displayed as a shade of gray or a color for each of the positions where data was recorded.
- The C-scan presentation provides an image of the features that reflect and scatter the sound within and on the surfaces of the test piece.

Sonogram- Recording of movement of Heart

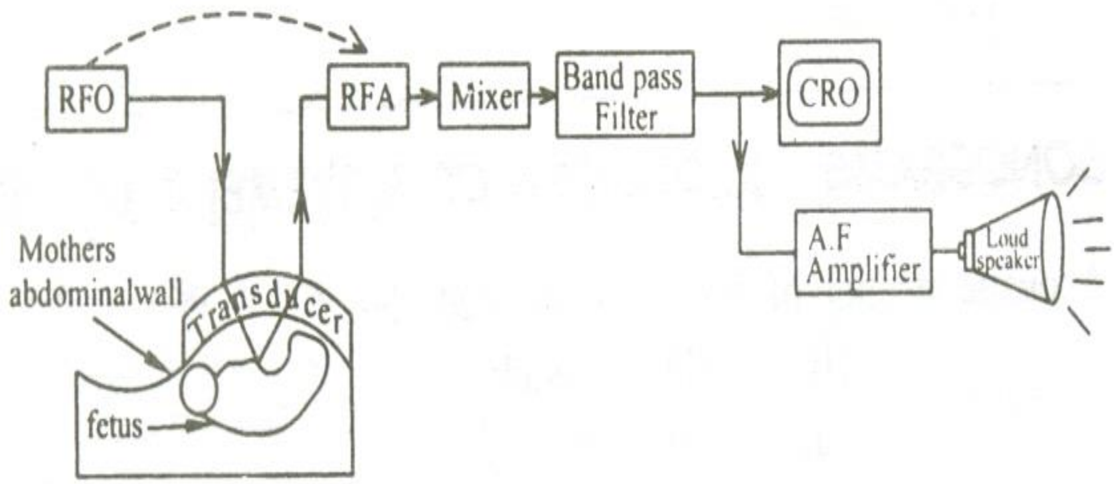
1.11.1 Fetal Heart Movement

Principle:

It works under the principle of Doppler Effect i.e., there is an apparent change in the frequency between the incident sound waves on the fetus and the reflected sound waves from the fetus.

Description:

It consists of a Radio Frequency Oscillator (RFO), for producing 2 MHz of frequency and RFA (Radio Frequency Amplifier) to amplify the receiver signals as shown in the figure 1.11.1

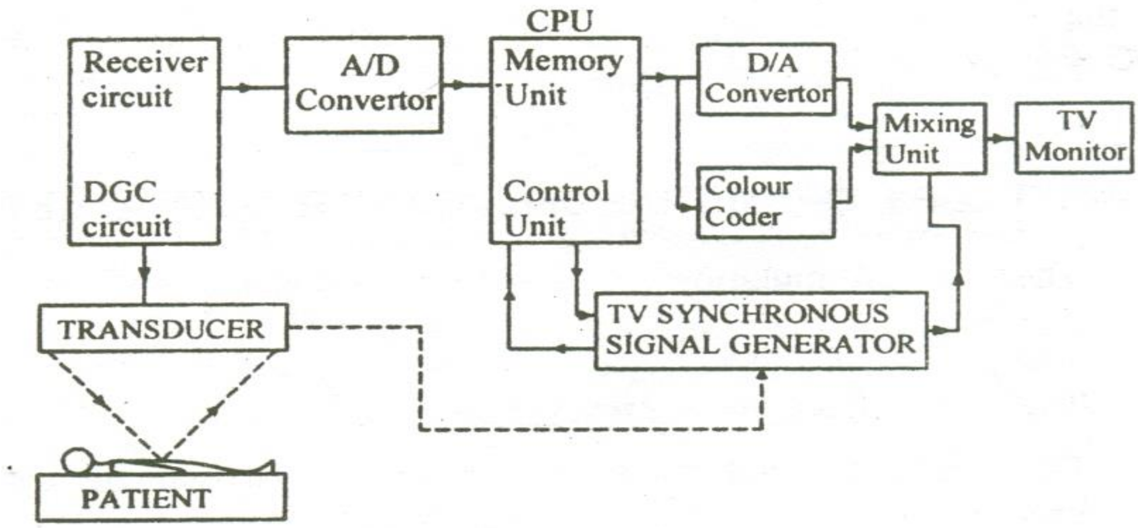


Working:

The transducer is fixed over the mother's abdominal wall, with the help of a gel or oil. RFO is switched on to drive the pulses and hence the transducer produces Ultrasonic waves of 2 MHz. These Ultrasonic waves are made to be incident on the fetus.

The reflected Ultrasonic waves from the fetus are received by the transducer and are amplified by RFA. Both the incident and the received signals are mixed by the mixer and is filtered to distinguish the various types of sound and finally the Doppler shift or change in frequency is measured. The movement of the heart can be viewed visually by CRO or can be heard by the Loud Speaker, after necessary amplification by AF.

Ultrasonic Imaging System



Principle of Working

- During the scanning of the body surface by Ultrasonic transducer, the Ultrasonic waves are transmitted into the patient's body.
- The echoes from the body are collected by the receiver circuit.
- Since some echoes come from the depth, they are weak; therefore, proper depth gain compensation is given by DGC circuit.
- Then these signals are converted into digital signals by an analog to digital converter and are stored in the memory of the Control Processing Unit (CPU) of a computer.
- Meanwhile, the control unit in the CPU receives the signals of transducer position and TV synchronous pulses. These signals generates X plate and Y plate address information's for the T.V monitor and is also stored in the memory of the CPU.
- The stored signals are processed and colour coded and is given to the digital to analog (D/A converter), which converts the digital signal into analog signal.
- Finally the mixing circuit mixes the analog signals and TV synchronous signals properly. The mixed signals are finally fed to the video section of the television monitor as shown in the figure
- The TV monitor produces the coloured Ultrasonic image of the internal part of the
  Body

Scanning Picture

UNIT III- THERMAL PHYSICS

PART - A

1. Define heat Conduction.

- Conduction is the process of transmission of heat from one point to another through substance (or some medium) without the actual motion of the particles (atoms / molecules) of the substance.

2. Define co-efficient of thermal conductivity and mention its unit.

- It is defined as the quantity of heat conducted per second normally across unit area of cross-section per unit temperature difference per unit length of the material.
- Its unit is watt / metre / Kelvin ($Wm^{-1} K^{-1}$)

3. What is basic principle behind Lee's disc method in determining thermal conductivity of bad conductor?

- The given bad conductor is taken in the form of disc is placed in between the metal disc (Lee's disc) and steam chamber. The steam is passed through the steam chamber. Heat conducted through bad conductor per second is calculated. Amount of heat lost per second by disc is also calculated.

At steady state

$$\begin{pmatrix} Heat\ conducted\ through\ the \\ bad\ conductor\ per\ second \end{pmatrix} = \begin{pmatrix} Amount\ of\ heat\ lost\ per\ second \\ by\ the\ disc \end{pmatrix}$$

From this, thermal conductivity of the bad conductor is calculated.

4. How are heat conduction and electrical conduction analogous to each other ?

	Heat conduction	Electrical conduction
1.	Heat is conducted from a point of higher temperature to a point of lower temperature.	Electricity is conducted from a point at higher potential to a point at lower potential.
2.	In metals, heat conduction is mainly due to free electrons.	In metals, electrical conduction is due to free electrons.
3.	The ability to conduct heat is measured by thermal conductivity.	The ability to conduct electricity is measured by electrical conductivity.

5. What are the characteristics of good and bad conductors ?

	Good conductors	Bad Conductors
1.	They have high electrical & thermal conductivity	They have very low electrical and thermal conductivity
2.	They can be easily heated or cooled.	They cannot be easily heated or cooled.
3.	**Examples :** Metals like iron, copper	**Examples :** Non metals like glass, wood.

6. What is thermal resistance?

- The thermal resistance of a body is a measure of its opposition to the flow of heat through it.

7. Explain why the specimen used to determine thermal conductivity of a bad conductor should have a larger area and smaller thickness.

- For a bad conductor with a small thickness and large area of cross - section, the amount of heat conducted increases (large), This will increase accuracy of the measurement.

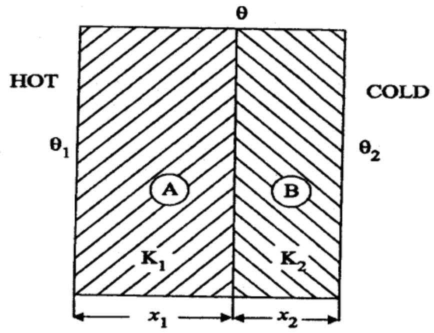
PART - B

1) EXPLAIN FLOW OF HEAT THROUGH COMPOUND MEDIA.

Material bars in series

Let us consider a compound media of two different materials A and B with thermal conductivities K_1 and K_2 and thickness x_1 and x_2.

The temperatures of the outer faces of A and B are θ_1 and θ_2. The temperature of the surface in contact is θ. When the steady state is reached, the amount of heat flowing per second (Q) through every layer is same.



After the steady state is reached,

Amount of heat flowing through the material (A) per second

$$Q = \frac{K_1 A (\theta_1 - \theta)}{x_1} \quad \text{------ (1)}$$

Amount of heat flowing through the material (B) per Second

$$Q = \frac{K_2 A (\theta - \theta_2)}{x_2} \quad \text{----- (2)}$$

The amount of heat flowing through the materials A and B is equal in steady state conditions.

Hence, the eqns (1) & (2) are equal

$$\frac{K_1 A (\theta_1 - \theta)}{x_1} = \frac{K_2 A (\theta - \theta_2)}{x_2} \quad \text{----- (3)}$$

Rearranging the eqn (3), we have

$$K_1 A (\theta_1 - \theta) x_2 = K_2 A (\theta - \theta_2) x_1$$

$$K_1 \theta_1 x_2 - K_1 \boldsymbol{\theta} x_2 = K_2 \boldsymbol{\theta} x_1 - K_2 \theta_2 x_1$$

Rearranging,

$$K_1\theta_1 x_2 + K_2\theta_2 x_1 = K_2\boldsymbol{\theta} x_1 + K_1\boldsymbol{\theta} x_2$$

$$K_1\theta_1 x_2 + K_2\theta_2 x_1 = \boldsymbol{\theta}\,(K_2 x_1 + K_1 x_2)$$

$$\theta = \frac{K_1\theta_1 x_2 + K_2\theta_2 x_1}{K_2 x_1 + K_1 x_2} \qquad \text{------ (4)}$$

This is the expression for interface temperature of two composite slabs in series.

Substituting for $\boldsymbol{\theta}$ in equation (1), We get

$$Q = \frac{K_1 A}{x_1}\left[\theta_1 - \left(\frac{K_1\theta_1 x_2 + K_2\theta_2 x_1}{K_2 x_1 + K_1 x_2}\right)\right]$$

$$= \frac{K_1 A}{x_1}\left[\frac{[\theta_1(K_2 x_1 + K_1 x_2) - (K_1\theta_1 x_2 + K_2\theta_2 x_1]}{K_2 x_1 + K_1 x_2}\right]$$

$$= \frac{K_1 A}{x_1}\left[\frac{[(K_{2\,\theta_1} x_1 + K_1\,\theta_1 x_2) - K_1\theta_1 x_2 - K_2\theta_2 x_1]}{K_2 x_1 + K_1 x_2}\right]$$

$$= \frac{K_1 A}{x_1}\left[\frac{[(K_{2\,\theta_1} x_1) - K_2\theta_2 x_1]}{K_2 x_1 + K_1 x_2}\right]$$

$$= \frac{K_1 A\, K_2 x_1\,(\theta_1 - \theta_2)}{x_1[K_2 x_1 + K_1 x_2]}$$

$$= \frac{K_1 A\, K_2\,(\theta_1 - \theta_2)}{[K_2 x_1 + K_1 x_2]}$$

$$= \frac{A(\theta_1 - \theta_2)}{\frac{K_2 x_1}{K_1 K_2} + \frac{K_1 x_2}{K_1 K_2}}$$

The amount of heat flowing per second through the compound wall of two materials.

$$Q = \frac{A(\theta_1 - \theta_2)}{\frac{x_1}{K_1} + \frac{x_2}{K_2}} \text{------------ (5)}$$

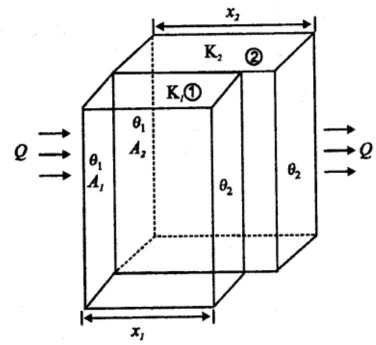
This method can also be extended to composite slab with more than two slabs.

In general for any number of slabs, the amount of heat conducted per sec is given by

$$Q = \frac{A(\theta_1 - \theta_2)}{\Sigma\left(\frac{x}{K}\right)} \qquad \text{--------(6)}$$

Material in Parallel

Consider a composite media of two different materials A and B with thermal conductivities K_1 and K_2 and thicknesses x_1 and x_2. They are arranged in parallel as shown in fig.



The faces of the material A and B are at temperature θ1 and the other end faces of A and B are at temperature θ_2 . A_1 and A_2 are the area of cross - section of the materials.

Amount of heat flowing through the first material (A) in one second.

$$Q_1 = \frac{K_1 A_1(\theta_1 - \theta_2)}{x_1} \text{----- (1)}$$

Similarly

Amount of heat flowing through the second material (B) in one second.

$$Q_2 = \frac{K_2 A_2(\theta_1 - \theta_2)}{x_2} \text{-----(2)}$$

The total heat flowing through these materials per second is equal to the sum of Q_1 and Q_2.

$$Q = Q_1 + Q_2$$

$$= \frac{K_1 A_1(\theta_1 - \theta_2)}{x_1} + \frac{K_2 A_2(\theta_1 - \theta_2)}{x_2} \text{----- (3)}$$

Amount of heat flowing per second

$$Q = (\theta_1 - \theta_2)\left[\frac{K_1 A_1}{x_1} + \frac{K_2 A_2}{x_2}\right] \text{----- (4)}$$

In general, the net amount of heat flowing per second parallel to the composite slabs is given by

$$Q = (\theta_1 - \theta_2)\sum\frac{KA}{x} \text{----- (5)}$$

2) EXPLAINFORBES METHOD - THEORY AND EXPERIMENT.

This is one of the earliest method to find the absolute thermal conductivity of metals.

Theory of the Experiment

- Consider a long rod. This rod is heated at one end and a steady state is reached after some time.

Amount of heat flowing per second across the cross-section A at the point B

$$= \text{KA} \left(\frac{d\theta}{dt}\right)_B$$

Consider an element of thickness dx of the rod.

Mass of the element = (Adx) ρ

Where ρ - density of the rod

[Mass = Volume x density]

Heat lost by the element per second

= Mass x Specific heat capacity x rate of fall of temperature

$= (Adx)\rho \text{ x S x } \frac{d\theta}{dt}$ ----- (2)

Total heat lost by the portion of the rod between section B and the end C

$$= \int_C^B (Adx)\ \rho\ S \frac{d\theta}{dt} \text{ ----- (3)}$$

Amount of heat flowing per second across the cross Section at the point B.	=	Heat lost by radiation by radiation by the rod. beyond the section B.

$$\text{KA} \left(\frac{d\theta}{dx}\right)_B = \int_C^B (Adx)\ \rho\ S \frac{d\theta}{dt} \text{ ----- (4)}$$

$$K = \frac{\rho\ S \int_C^B \frac{d\theta}{dt}\, dx}{\left(\frac{d\theta}{dt}\right)_B} \text{ ------ (5)}$$

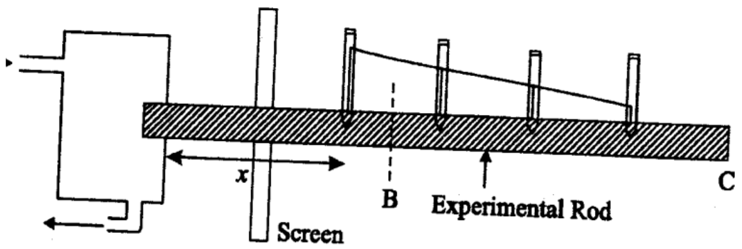
Experiment consists of two parts

1. Static experiment to find $\left(\frac{d\theta}{dt}\right)_B$

2. Dynamic experiment to find $\frac{d\theta}{dt}$ and $\int_C^B \frac{d\theta}{dt}\, dx$

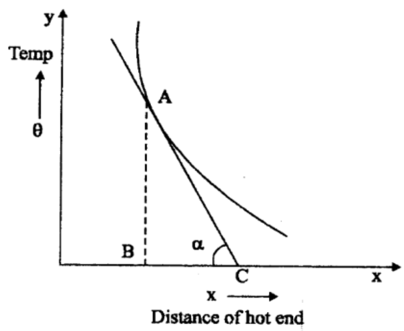
1. Static Experiment

The specimen metal is taken in the form of a long rod. One end of this rod is heated by a steam chamber. The rod has a series of holes into which thermometers are fitted. These thermometers record temperatures at different points along the rod.



When the steady state is reached, the temperature (**θ**) shown by the thermometers of the rod and their respective distances (x) from the hot end are noted.

A graph is drawn between the temperature (**θ**) and the distance (x) from the hot end.



The Value of $\left(\frac{d\theta}{dt}\right)_B$ is obtained by drawing a tangent to the curve at a point B.

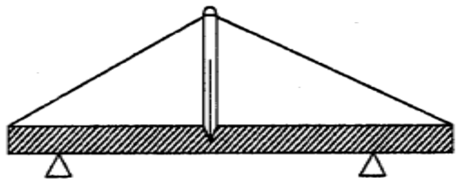
If this tangent makes an angle α with the x axis, then from the graph.

$$\left(\frac{d\theta}{dt}\right)_B = \frac{AB}{BC} = \tan \alpha$$

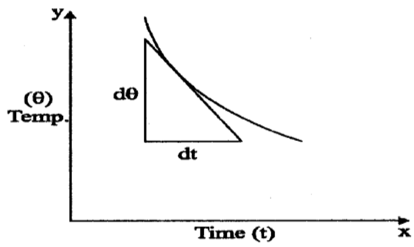
2. Dynamic experiment

A piece of the original rod is heated to the same temperature as that of the hot end in the static experiment. The heated piece of the rod is suspended in air.

Now, it is allowed to cool. Its temperature is noted at regular intervals of time by a thermometer place in a hole at the centre.

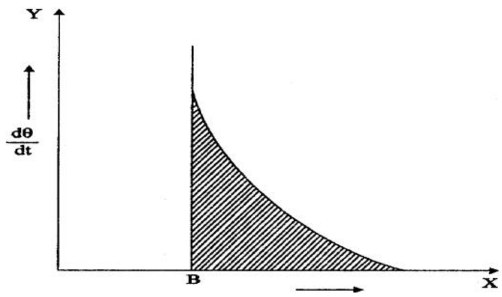


A graph is drawn between temperature (**θ**) and time (t)



From this graph, the value of $\frac{d\theta}{dt}$ for various values of **θ** are determined by drawing tangents at various points of the cooling curve.

From the graph between temperature ɵ and the distances of hot end x for various values of temperature ɵ are obtained. Now, third graph is drawn between $\frac{d\theta}{dt}$ and the corresponding values of x.



The curve is extended to meet the x - axis. Corresponding to the point B, a point is located on the curve.

The area bounded by the curve, x - axis and the ordinate passing through B is $\int_C^B \frac{d\theta}{dt}$ dx

The area of the shaded portion is determined.

We know that $$K = \frac{\rho\, S \int_C^B \frac{d\theta}{dt}\, dx}{\left(\frac{d\theta}{dt}\right)_B}$$

substituting the values in the above equation, we have

$$\mathbf{K} = \frac{\rho\, S \times (Area\ of\ the\ shaded\ portion)}{\tan\alpha}$$

Hence, K is determined

Merits

- It is one of the earliest method to determine the absolute thermal conductivity of the material.

Demerits

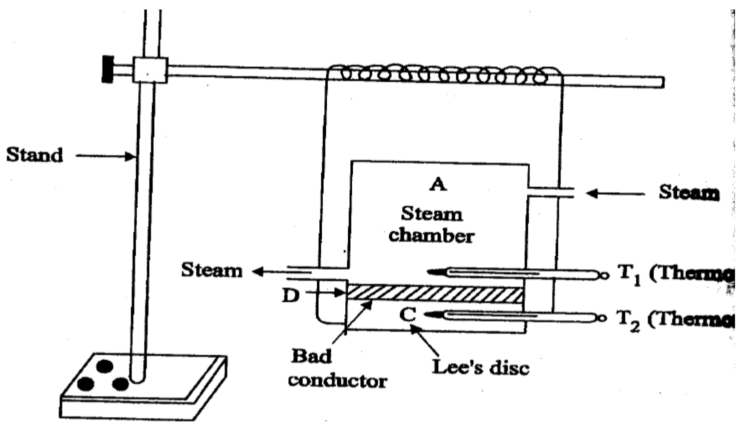
- It is tedious method and requires a lot of time for the completion of the experiment and drawing the three graphs.
- The specific heat capacity of the material of the rod does not remain constant at different temperatures as assumed.
- The distribution of heat is not uniform along the bar in the two experiments. Therefore, this experiment is not accurate.

3) EXPLAIN LEE'S DISC METHOD - THEORY AND EXPERIMENT

The thermal conductivity of bad conductors like glass, ebonite or card board is determined by this method.

Description

- The apparatus consists of a circular metal disc or slab (C) (Lee's disc) of radius r and thickness H suspended by the strings from a stand .
- The given bad conductor (such as glass, ebonite) is taken in the form of a disc (D). This bad conductor has the same diameter as that of the slab is placed on the bad conductor. There are holes in steam chamber and slab into which thermometers T_1 and T_2 are inserted to record the respective temperatures.



Working

- Steam is passed into the steam chamber until the temperatures in the chamber and the slab are steady. When thermometers T_1 and T_2 show steady temperatures, their readings $\theta_1$and θ_2 respectively are noted. The radius (r) and thickness (d) of the disc D are also measured.

Observation and calculation

Thickness of the bad conductor	-	d
Radius of the bad conductor and metal disc	-	r
Mass of the slab (Lee's disc)	-	M
Thickness of the metal disc	-	h
Steady temperature in the steam chamber	-	θ_1
Steady temperature in the slab	-	θ_2
Thermal conductivity of the bad conductor	-	K
Rate of cooling of the slab at θ_2	-	R
Specific heat capacity of the slab	-	S

Area of the cross section $A = \pi r^2$

Amount of the heat conducted through the disc D per second

$$Q = \frac{KA\,(\theta_1 - \theta_2)}{d} = \frac{K\pi r^2}{d}(\theta_1 - \theta_2)$$

- At this state all the heat conducted through the bad conductor is completely radiated by the bottom flat surface and the curved surface of the slab C.
- Amount of heat lost per second by the slab C.

Q = Mass x Specific heat capacity x Rate of cooling

Q = MSR

At steady state,

Heat conducted through the bad conductor per second	=	Heat lost per second by the slab C

Hence, equations (1) and (2) are equal

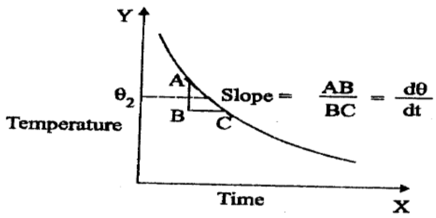
$$\frac{K\pi r^2}{d}(\theta_1 - \theta_2) = MSR$$

$$K = \frac{MSRd}{\pi r^2(\theta_1 - \theta_2)}$$

(ii) Determination of rate of cooling R.

- The bad conductor is removed and the steam chamber is placed directly on the slab. The slab is heated to a temperature about 5℃ higher than θ_2. The steam chamber is removed and the slab alone is allowed to cool.
- As the slab cools, the temperatures of the slab are noted at regular intervals of time (0.5 minute) until the temperature of the slab falls to about 5℃ below θ_2.

The temperature - time graph is drawn and the rate of cooling $\frac{d\theta}{dt}$ at the steady temperature θ_2 is determined.



- During the first part of the experiment, before the removal of bad conductor and steam chamber, the top surface of the slab is covered surface area of the slab is covered by the bad conductor.
- Radiation is taking place only from the bottom surface area and curved surface area of the slab.

Total area = $\pi r^2 + 2\pi rh = \pi r\,(r+2h)$

In the second part of the experiment, heat is radiated from top surface area, bottom surface area and curved sides. i.e., over entire surface area.

$\pi r^2 + \pi r^2 + 2\pi rh = 2\pi r^2 + 2\pi rh = 2\pi r\,(r + h)$

As the rate of cooling is directly proportional to the surfaces that are exposed (other condition being equal).

$$\frac{R}{\frac{d\theta}{dt}} = \frac{\pi r\,(r+2h)}{2\pi r\,(r+h)} = \frac{r+2h}{2(r+h)} = \frac{r+2h}{(2r+2h)}$$

$$R = \frac{r+2h}{(2r+2h)}\left(\frac{d\theta}{dt}\right)$$

Substituting for R in equation (3), We have

$$K = \frac{MSd\left(\frac{d\theta}{dt}\right)}{\pi r^2(\theta_1 - \theta_2)}\,\frac{r+2h}{(2r+2h)}$$

Thus thermal conductivity of the bad conductor is determined.

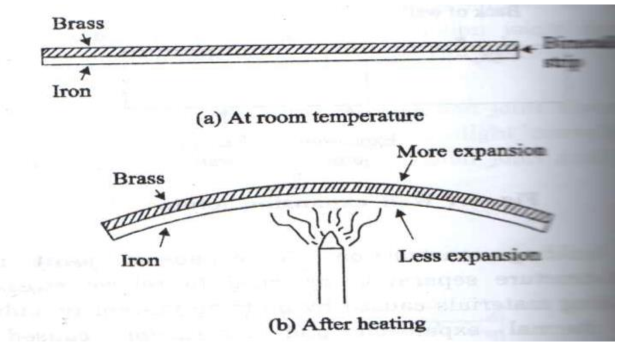
4) EXPLAIN BIMETALLIC STIRPS

Definition

A bimetallic strip means a strip made of two metals of different expansions coefficients joined together .It is like compound bar.

Principle

It operates on the principle that different metals have different coefficients of expansion.



Description and working

- Two strips of brass and iron of equal lengths are joined together to form a bimetallic strip.
- This bimetallic strip is straight at room temperature.
- Now, it is heated by using a burner. On heating, the metallic strip bends to form a curve in such a way that brass remains on the outside of the curve .
- This means that brass strip has become longer than the iron strip after heating , that is ,brass expands more than iron for the same rise in temperature.
- It is obvious that a bimetallic strip bends due to the unequal expansion rate of the two metals.
- In fact on heating, of the bimetallic strip bends towards iron side. If ,however , the bimetallic strip shown in fig.is cooled in freezing mixture , then it bends the other way showing that brass contracts more than iron.

Applications of bimetallic strips

- They are used as thermo-switches in automatic electrical heating and cooling appliances like thermostats, electric ovens, electric irons , fire alarms , and bimetallic thermo meters . A thermoswitch is a switch which works by the action of heat.

Quantum Physics

Formula

S.No	Description	Formula
1.	Stefan- Boltzmann's law	E α T^4 (or) E = σT^4 Where σ = 5.67X10^{-8}W/m^2k^4
2.	Rayleigh- Jean's law	E = 8πkT/λ^4
3.	Wien's displacement law	$\lambda_m T = constant$ $\lambda_m \propto \frac{1}{T}$
4.	Wien's radiation law	$E_\lambda = \frac{8\pi hc}{\lambda^5}\frac{1}{e^{-hc/\lambda kT}}$ $E_\lambda = C_1\lambda^{-5}e^{-C_2/\lambda T}$
5.	Planck's law of radiation	$E_\lambda = 8\pi hc/(\lambda^5 e^{hv/kt}-1)$
6.	de- Broglie wave equation	λ = h/p ; $\lambda = h/mv$
7.	de- Broglie wavelength in terms of energy	$\lambda = \frac{h}{\sqrt{2mE}}$
8.	de- Broglie wavelength associated with electrons	$\lambda = \frac{h}{\sqrt{2meV}}$
9.	Compton wavelength or Compton Shift	$d\lambda = \frac{h}{m_0 c}(1-\cos\theta)$
10.	The total wave function	$\Psi = \psi e^{-i\omega t}$
11.	Schrodinger's time independent wave equation	$\nabla^2\psi + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$ or $\nabla^2\psi + \frac{2m}{\hbar^2}(E - V)\psi = 0$

12.	Schrodinger's time dependent wave equation	$(-\frac{\hbar^2}{2m}\nabla^2 + V)\psi = i\hbar\frac{\partial\psi}{\partial t}$ $H\psi = E\psi$
13	Energy of a particle in one dimensional box	$E_n = \frac{n^2h^2}{8ma^2}$
14.	Wave function of a particle in one dimensional box	$\psi_n(x) = A\sin\frac{n\pi x}{a}$
15.	The normalised eigen function of a particle	$\psi_n = \sqrt{\frac{2}{a}}\sin\frac{n\pi x}{a}$

Part- A

1**. Mention some important applications of quantum physics?**

- It is used to explain the concept of photo electric effect.
- Specific heat of solids at low temperature is explained successfully.
- The atomic structure and the origin of spectral lines are explained by Bohr based on quantum concepts.
- X-rays scattering is explained by Compton based on quantum ideas.
- Energy distribution in black body radiation is explained.

2. What is a Black body?

A body which absorbs and emits all the frequency of radiation fall on it, it is called a perfect black body.

Characteristics:

- There is no perfect black body in practical.
- We can make a black body artificially by painting the black over the surface.
- It is a perfect absorber and radiator.

3. State Stefan- Boltzmann's law?

The total power per unit surface area radiated by a black body is directly proportional to the temperature.

$$E \propto T^4 \quad \text{(or)} \quad E = \sigma T^4 \quad , \text{Where } \sigma = 5.67\text{X}10^{-8} W/m^2k^4$$

4. State wein's law of energy distribution?

The product of emitted wavelength at maximum energy (λ_m) and absolute temperature (T) is constant.

$$\lambda_m T = 2.89\text{X}10^{-3} \text{ mK}$$

This law also states that the maximum energy radiated is directly proportional to the fifth power of temperature. $E_{max} = T^5$

The energy density of emitted radiation $E = A\nu^3 e^{-\beta\nu/T}$

This law holds good only for higher frequencies.

5. State Rayleigh- Jean's law?

The energy distribution is directly proportional to absolute temperature and inversely proportional to the wavelength of radiation.

$$E = 8\pi kT/\lambda^5$$

Where $k = 1.38\text{X}10^{-23} JK^{-1}$ is Boltzmann's constant.

This law holds good only for Lower frequencies.

6. State Planck's hypothesis.

- The radiation energy emitted by Black body is in the form of discrete packets or quanta called photons.
- If the temperature of body increases, the emitted radiation frequency also increases.
- The emitted radiation possess energy $h\nu$ and momentum h/λ.

7. State Planck's law of radiation?

The energy emitted in the form of packets or quanta called photons is given by

$$E = nh\nu.$$

Where n = 1,2,3 etc.

In black body radiation total energy of photons within the wavelength range λ and λ+d λ is given by

$$E_\lambda = 8\pi hc/(\lambda^5 e^{h\nu/kt}-1)$$

8. Define Compton effect.

When a photon of energy $h\nu$ colloids with a substance , the scattering beam consists of two components.

One has the same frequency or wavelength as the incident ray.

Other has low frequency or high wavelength than the incident ray.

This effect is called as Compton effect. The change in wavelength is called Compton shift.

9. What are matter waves or De-broglie waves?

The waves associated with the matter particles (molecule, atom, proton, neutron, electron) are called matter waves or de Broglie waves.

10. What is de- Broglie wave equation?

A photon of frequency ν has the momentum $P = h\nu/c$

$$\nu = c/\lambda \quad ; P = h/\lambda$$

W.k.t $\lambda = h/P$; $\lambda = h/mv$

If E_k is the k.E of the material particle , $p = \sqrt{(2mE_k)}$

If a charged particle carrying charge q is accelerated through a potential difference V volts then K.E $E_k = qv$

$$\lambda = h/\sqrt{(2mqV)}$$

11. State the properties of matter waves?

If mass of the particle is smaller, the wavelength associated it is longer.

If velocity of the particle is smaller, the wavelength associated is longer.

Matter waves are electromagnetic wave.

Velocity of matter wave is not constant.

12.What is physical significance of a wave function?

As the wave function Ψ is a complex quantity, it can be used to measure the variation of matter wave. It does not have direct physical meaning.

It is used to identify the energy states of a particle in an atomic structure.

$\Psi\Psi^*$ or $|\Psi|^2$ is the probability density function. $\Psi\Psi^*dx\,dy\,dz$ gives the probability of finding the electron in the region of space between x and x +dx , y+dy and z+dz.

$$\int_{-a}^{a} \Psi\Psi^* dx\, dy\, dz = 1$$

13.What is the principle of travelling electron microscope?

When the high energy accelerated electrons are focussed on a sample, they can pass through the sample and image in the screen either by transmitted beam or diffracted beams. This gives the three dimensional image of the sample.

14. Define eigen value and eigen function?

Eigen value is defined as energy of the particle and is denoted by letter E_n.

Eigen function is defined as the wave function of the particle and is denoted by the letter Ψ_n.

15. Define degeneracy?

The combinations of quantum numbers have same eigen values but different eigen functions.This kind of states are called degenerate state. if both the eigen function and eigen value is same then it is called non-degenerate state.

Part- B

1.Derive planck's law for black body radiation and hence deduce wien's law and Rayleigh jeans law.

Let us consider N no.of oscillators. E_{Tot} is Total energy.

The average energy of an oscillator

$$\mathbf{E_{avg} = E_{Tot}/ N \quad ....(1)}$$

Where $N_0, N_1, N_2, N_3, ...N_r \rightarrow$ Oscillators

$0, 1E, 2E, 3E, 4E, 5E, ... rE \rightarrow$ Corresponding energy of oscillator.

Total no.of oscillators $N = N_0+N_1+N_2+N_3+......+N_r$

Total energy of oscillators $E_{Tot}= 0N_0+ 1EN_1+2EN_2+3EN_3+......+rEN_r$

According to Maxwell Boltzmann distribution function,

The no.of oscillator having energy rE ,

$$\mathbf{N_r = N_0e^{-rE / Kt} ....(2)}$$

Where k is called Boltzmann constant.

$r = 0,1,2,3,...$

For $r = 0$; $\quad N_0 = N_0e^0$

For r = 1; $N_1 = N_0 e^{-E/KT}$

For r = 2; $N_2 = N_0 e^{-2E/KT}$

For r = 3; $N_3 = N_0 e^{-3E/KT}$

For r = r; $N_r = N_0 e^{-rE/KT}$

Therefore $N = N_0 e^{0} + N_0 e^{-E/KT} + N_0 e^{-2E/KT} + N_0 e^{-3E/KT} + \ldots\ldots\ldots + N_0 e^{-rE/KT}$

Or

$$N = N_0 \left[1 + e^{-E/KT} + e^{-2E/KT} + e^{-3E/KT} + \ldots\ldots\ldots + e^{-rE/KT}\right]$$

W.K.T $\mathbf{1+x+x^2+x^3+\ldots = 1/1-x}$

The total no.of oscillators $N = \mathbf{N_0[1/1- e^{-rE/Kt}]}$**.....................(3)**

By substituting the values of $N_0, N_1, N_2, N_3 \ldots\ldots\ldots N_r$,the total energy can be written as $E_{tot} = 0\ N_0 e^{0} + E N_0 e^{-E/KT} + 2E\ N_0 e^{-2E/KT} + 3E\ N_0 e^{-3E/KT} + \ldots\ldots\ldots + rE\ N_0 e^{-rE/KT}$

$$E_{tot} = N_0\left[0 + E e^{-E/KT} + 2E e^{-2E/KT} + 3E e^{-3E/KT} + \ldots\ldots\ldots + rE e^{-rE/KT}\right]$$

$$E_{tot} = N_0\ E e^{-E/KT}\ \left[0 + 1 + e^{-E/KT} + 3e^{-2E/KT} + \ldots\ldots\ldots + re^{-(r-1)E/KT}\right]$$

W.K.T $\mathbf{1+2x+3x^2+4x^3+\ldots+rx^{r-1} = 1/(1-x)^2}$

Total energy of oscillators

$$E_{tot} = N_0\ E e^{-E/KT}\ \left[\ 1/(1-e^{-E/KT})^2\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Substitute the values of (4) in (1),

$$\overline{E} = \frac{E_{TOT}}{N} = \frac{N_0 E e^{-E/KT}}{N_0\left[\frac{1}{(1-e^{-E/KT})}\right]}\left[\frac{1}{(1-e^{-E/KT})^2}\right]$$

$$\overline{E} = \frac{E e^{-E/KT}}{(1-e^{-E/KT})}$$

$$\overline{E} = \frac{E}{\frac{1-e^{-E/KT}}{e^{-E/KT}}}$$

$$\overline{E} = \frac{E}{\frac{1}{e^{-E/KT}} - 1}$$

$$\overline{E} = \frac{E}{e^{E/KT} - 1}$$

$$\overline{E} = \frac{h\nu}{e^{h\nu/KT} - 1} \text{ ....(5)}$$

The no.of oscillators per unit volume within the range of frequency v+dv,

$$N = \frac{8\Pi\nu^2}{c^3} d\nu \text{ ....(6)}$$

The energy density = No.of oscillators per unit volume x Average energy of an oscillator

$$E_\nu d\nu = N\ \overline{E}$$

$$E_\nu d\nu = \frac{8\Pi\nu^2}{c^3} d\nu \frac{h\nu}{e^{h\nu/KT} - 1} \text{ ....(7)}$$

$$E_\nu = \frac{8\Pi h\nu^3}{c^3} \frac{}{e^{h\nu/KT} - 1} \text{ ....(8)}$$

or

w.k.t $\nu = c/\lambda$ or $d\nu = \frac{-c}{\lambda^2} d\lambda$

$$|d\nu| = \left|[\frac{-c}{\lambda^2}]d\lambda\right| = \left[\frac{c}{\lambda^2}\right]d\lambda$$

$$E_\lambda = \frac{8\Pi hc}{\lambda^5}\left[\frac{1}{e^{hc/\lambda kT} - 1}\right] \text{ ....(9)}$$

This law holds good for all the experimental results.

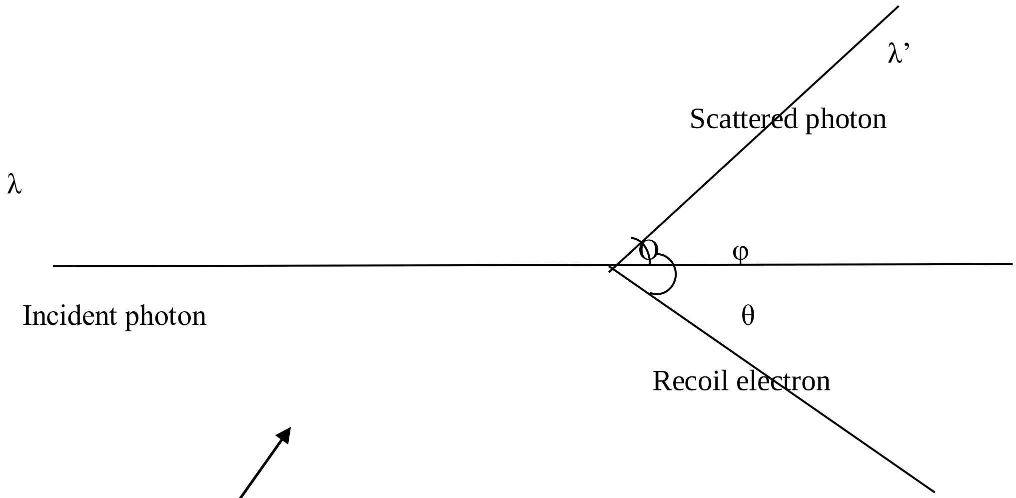
2.Define Compton scattering? Derive an expression for the Compton wavelength of the scattered photon?

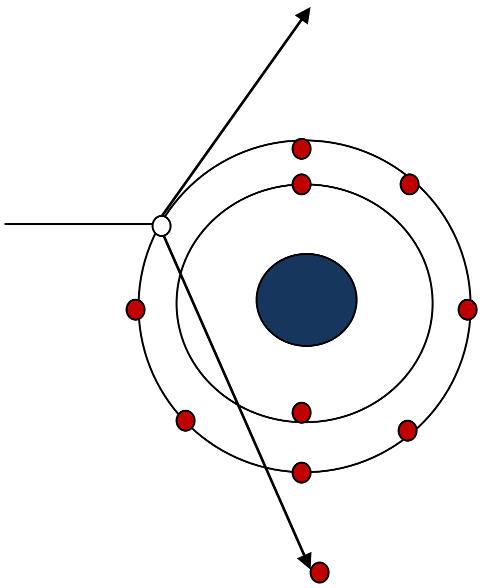
When a photon of energy hν colloids with a substance , the scattering beam consists of two components.

One has the same frequency or wavelength as the incident ray.

Other has low frequency or high wavelength than the incident ray.

This effect is called as Compton effect. The change in wavelength is called Compton shift.





Incident photon energy =h ν

Scattered photon energy = hν’

Consider a high frequency photon strikes an electron at rest. Scattered angle is φ to x axis.

The electron of atom gains energy due photon collision. Then it moves with the velocity v at an angle θ to x axis i.e recoil velocity.

Total energy before collision

Energy of incident photon = hν

Energy of an electron at rest = m_0c^2

C →Velocity of light

Total energy before coliision = $h\nu + m_0c^2$

Total energy after collision

Energy of scattered photon = $h\nu'$

Energy of recoiled electron = mc^2

Total energy after collision = $h\nu' + mc^2$

According to conservation law of energy,

Total energy before collision = Total energy after collision

$h\nu + m_0c^2 = h\nu' + mc^2$..................(1)

Total momentum along x axis before collision

Momentum of photon = $h\nu / c$

Momentum of electron = 0

Total momentum along x axis before collision = $\frac{h\nu}{c} + 0 = \frac{h\nu}{c}$

Total momentum along x axis after collision

Momentum of scattered photon = $\frac{h\nu'}{c}\cos\phi$

Momentum of recoiled electron = $mv\cos\theta$

Total momentum along x axis = $\frac{h\nu'}{c}\cos\phi + mv\cos\theta$

According to conservation law of momentum in along axis,

Total momentum before collision = Total momentum after collision

$$\frac{h\nu}{c} = \frac{h\nu'}{c}\cos\phi + mv\cos\theta$$

$$\frac{h\nu}{c} - \frac{h\nu'}{c}\cos\phi = mv\cos\theta$$

$$\frac{h}{c}(\nu - \nu'\cos\phi) = mv\cos\theta$$

$h(\nu - \nu'\cos\phi) = mvc\cos\theta$ or $mvc\cos\theta = h(\nu - \nu'\cos\phi)$ ....(2)

Total momentum along y axis before collision

Momentum of photon = 0

Momentum of electron = 0

Total momentum along y axis before collision = 0

Total momentum along y axis after collision

Momentum of scattered photon = $\frac{h\nu'}{c}\sin\phi$

Momentum of recoiled electron = - mvsinθ (-ve sign indicates -ve y direction)

Total momentum along y axis after collision = $\frac{h\nu'}{c}\sin\phi$ - mvsinθ

According to conservation law of momentum ,

Momentum before collision = Momentum after collision

$$0 = \frac{h\nu'}{c}\sin\phi - mv\sin\theta$$

$$\frac{h\nu'\sin\phi - mvc\sin\theta}{c} = 0$$

$h\nu'\sin\varphi - mvc\sin\theta = 0$ or $mv\sin\theta = h\nu'\sin\phi$ ....(3)

Squarring equ (2) & (3) and adding,

$$(mvc\cos\theta)^2+(mvc\sin\theta)^2 = h^2(\nu-\nu'\cos\varphi)^2+(h\nu'\sin\varphi)^2$$

L.H.S $m^2 v^2c^2\cos^2\theta+m^2v^2c^2\sin^2\theta = m^2 v^2c^2(\sin^2\theta+\cos^2\theta) = m^2 v^2c^2$

R.H.S $h^2(v^2-2vv'\cos\varphi+v'^2\cos^2\varphi)+h^2v'^2\sin^2\varphi$

$$h^2(v^2-2vv'\cos\varphi+v'^2\cos^2\varphi+v'^2\sin^2\varphi)$$

$$h^2(v^2-2vv'\cos\varphi+v'^2(\sin^2\varphi+\cos^2\varphi))$$

$h^2(v^2-2vv'\cos\varphi+v'^2)$ ($\because \sin^2\varphi+\cos^2\varphi = 1$)

$\therefore m^2v^2c^2 = h^2(v^2-2vv'\cos\varphi+v'^2)$ ....(4)

From equ (1), $mc^2 = h(v-v')+m_0c^2$...........(5)

Squaring equ (5) on both sides, $m^2c^4 = (h(v-v')+m_0c^2)^2$

$m^2c^4 = h^2(v^2-2vv'+v'^2)+2h(v-v')m_0c^2+m_0^2c^4$.............(6)

Subtracting equ (4) from (6),

$$m^2c^4-m^2v^2c^2 = h^2(v^2-2vv'+v'^2)+2h(v-v')m_0c^2+m_0^2c^4 - h^2(v^2-2vv'\cos\varphi+v'^2)$$

$$m^2c^2(c^2-v^2) = -2h^2vv'+2h^2vv'\cos\varphi+2h(v-v')m_0c^2+m_0^2c^4$$

$$m^2c^2(c^2-v^2) = -2h^2vv'+2h^2vv'\cos\varphi+2h(v-v')m_0c^2+m_0^2c^4$$

$$m^2c^2(c^2-v^2) = -2h^2vv'(1-\cos\varphi)+2h(v-v')m_0c^2+m_0^2c^4 \text{.............(7)}$$

The variation of mass with velocity from Special theory relativity,

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \text{..................................(8)}$$

Squaring equ (7) on both sides,

$$m^2 = \frac{m_0^2}{1-\frac{v^2}{c^2}} = \frac{m_0^2}{\frac{c^2-v^2}{c^2}} = \frac{m_0^2c^2}{c^2-v^2}$$

$$m^2(c^2-v^2) = m_0^2c^2$$

Multiplying c^2 on both sides, $m^2c^2(c^2-v^2)=m_0^2c^4$..........................(9)

Substituting equ (9) in (7) $m_0^2c^4 = -2h^2vv'(1-\cos\varphi)+2h(v-v')m_0c^2+m_0^2c^4$

$2h(v-v')m_0c^2=2h^2vv'(1-\cos\varphi)$ or

$$\frac{v-v'}{vv'} = \frac{h}{m_0c^2}(1-\cos\phi)$$

$$\frac{v}{vv'} \quad \frac{v'}{vv'} = \frac{h}{m_0c^2}(1-\cos\varphi)$$

$$\frac{1}{v'} - \frac{1}{v} = \frac{h}{m_0c^2}(1 \quad \cos\varphi)$$

Multiplied by c on both sides of above equ

$$\frac{c}{v'}-\frac{c}{v} = \frac{hc}{m_0c^2}(1-\cos\phi) \quad \text{or} \quad \frac{c}{v'}-\frac{c}{v} = \frac{h}{m_0c}(1-\cos\phi)$$

-

$$\lambda' \quad \lambda = \frac{h}{m_0c}(1-\cos\varphi) \text{...........................(10)} \quad \text{or} \quad \{\because \frac{c}{v} = \lambda\}$$

$$d\lambda = \frac{h}{m_0 c}(1 - \cos\varphi)$$

Note:

The change in wavelength is due to angle of scattering.

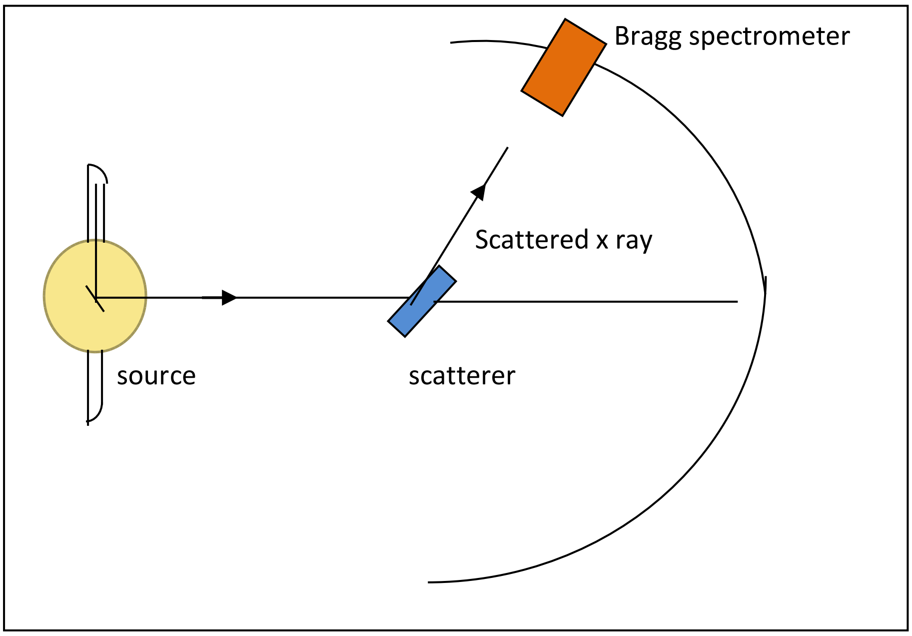
$d\lambda$ is independent of wavelength of incident radiation and nature of the substance.

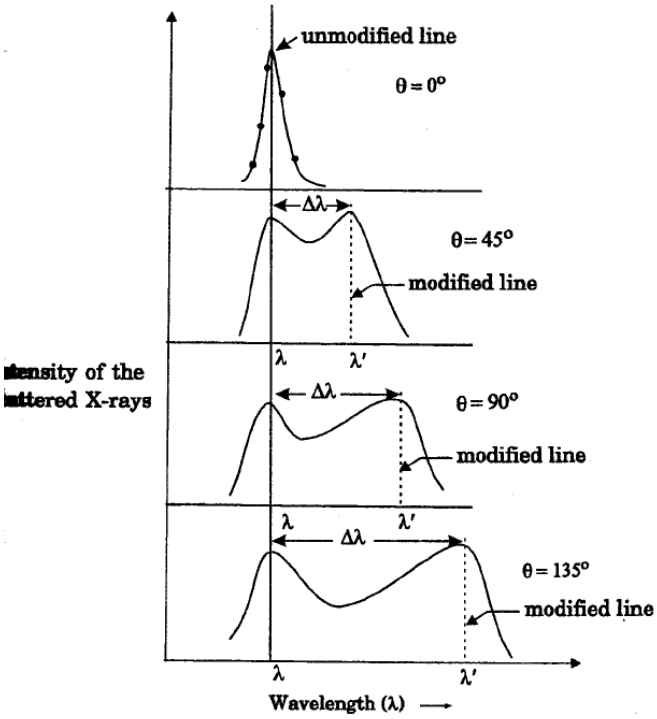
Case: 1 When $\theta = 0$, $\cos\theta = 1$ and hence $d\lambda = 0$

Case:2 When $\theta = 90$, $\cos\theta = 0$ and hence $d\lambda = h/m_0c = 0.0243A^0$

Case3: When $\theta = 180$, $\cos\theta = -1$ and hence $d\lambda = h/2m_0c = 0.0485A^0$

3.Describe the experimental verification of Compton scattering?





X-ray is allowed to fall on a scattering element.

The scattered ray is captured by a Bragg spectrometer.

The wave length of scattered ray is measured from every angle.

There exists a line of longer wave length, in addition to the incident wavelength.

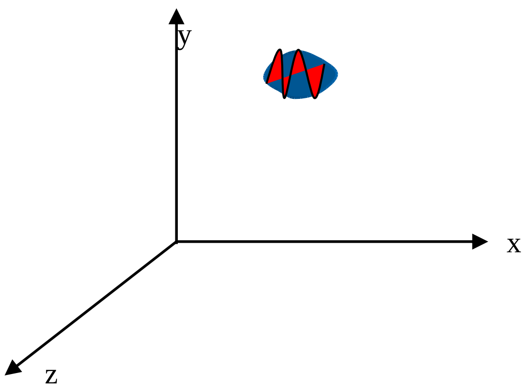
The difference between the two wavelengths is known as Compton shift.

Thus the Compton effect is proved experimentally. It states that the particle nature of radiation also.

Compton shift is the function of scattered angle. i.e shift increases for the increase of scattered angle of photon.

4. Derive the time independent Schrodinger equation for 3 dimensional motion.

Consider a wave pocket . x,y,z be the 3 co- ordinates. Ψ is the displacement of wave at any time t.



The classical differential equation of a wave motion,

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2} \quad \text{.................(1)}$$

Here v = wave velocity.

$$\nabla^2 \psi = \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2} \quad \text{............................(2)}$$

$$\nabla^2 = \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2}$$

Where ∇ is laplacian operator.

The solution of equ

$\psi(x,y,z) = \psi_0(x,y,z)e^{-i\omega t}$ ....(3)

$\psi_0(x,y,z)$ is a function of x,y,z.

By differentiating, $\frac{\partial \psi}{\partial t} = -i\omega\psi_0 e^{-i\omega t}$ and

$$\frac{\partial^2 \psi}{\partial t^2} = i^2\omega^2\psi_0 e^{-i\omega t}$$

$$\frac{\partial^2 \psi}{\partial t^2} = -\omega^2\psi \quad \text{.............(4)}$$

$$\nabla^2 \psi = -\frac{\omega^2}{v^2}\psi$$

$$\nabla^2 \psi + \frac{\omega^2}{v^2}\psi = 0 \quad \text{.......................(5)}$$

But angular frequency ω = 2πv = $2\pi\left(\left(\frac{v}{\lambda}\right)\right)$

$\because$ v = $\frac{v}{\lambda}$

$$\frac{\omega}{v} = \frac{2\pi}{\lambda}$$

$$\frac{\omega^2}{v^2} = \frac{4\Pi^2}{\lambda^2}$$

$$\nabla^2\psi + \frac{4\Pi^2}{\lambda^2}\psi = 0 \quad ....(6)$$

w.k.t the De-broglie $\lambda = \frac{h}{mv}$

$$\nabla^2\psi + \frac{4\Pi^2}{\frac{h^2}{m^2v^2}}\psi = 0$$

$$\nabla^2\psi + \frac{4\Pi^2 m^2 v^2}{h^2}\psi = 0$$

$$\nabla^2\psi + \frac{m^2v^2}{\frac{h^2}{4\Pi^2}}\psi = 0 \quad ....(7) \qquad \because \frac{h}{2\Pi} = \hbar$$

$$\nabla^2\psi + \frac{m^2v^2}{\hbar^2}\psi = 0$$

E (Total energy of the particle) = (Potential energy) V + Kinetic energy ($\frac{1}{2}$ mv^2)

........(8)

E – V = $\frac{1}{2}$ mv^2

mv^2 = 2(E-V)

multiplying by m on both sides $m^2v^2 = 2m(E-V)$
Substituting equ (8) in (9) we get ,

$$\nabla^2\psi + \frac{2m(E-V)}{\hbar^2}\psi = 0 \quad ....(9)$$

As there is no term to define time, it is called time independent equation.

5. Derive the time dependent Schrodinger equation for 3 dimensional motion.

This equation is derived from Schrodinger time independent equation.

The solution of classical diff equation of wave motion

$\psi(x,y,z) = \psi_0(x,y,z)e^{-i\omega t}$ ....(1)

By differentiating w.r.t 't' time, $\frac{\partial\psi}{\partial t} = -i\omega\psi_0 e^{-i\omega t}$

$\frac{\partial\psi}{\partial t} = -i(2\Pi v)\psi_0 e^{-i\omega t}$ here $\omega = 2\pi v$

$$\frac{\partial\psi}{\partial t} = -i2\Pi v\psi$$

$\frac{\partial\psi}{\partial t} = -i2\Pi\frac{E}{h}\psi$ $\because E = hv$

$\frac{\partial\psi}{\partial t} = -i\frac{E}{\frac{h}{2\Pi}}\psi$ or $\frac{\partial\psi}{\partial t} = -i\frac{E}{\hbar}\psi$

Multiplying i on both sides, $i\frac{\partial\psi}{\partial t} = -i^2\frac{E}{\hbar}\psi$ or $i\frac{\partial\psi}{\partial t} = \frac{E}{\hbar}\psi$

$$i\hbar\frac{\partial\psi}{\partial t} = E\psi$$

-

$$\nabla^2\psi + \frac{2m(E-V)}{\hbar^2}\psi = 0$$

Substitute the value of E ψ

$$\nabla^2\psi + \frac{2m}{\hbar^2}\quad i\hbar\frac{\partial\psi}{\partial t} - V\psi \quad = 0$$

$$\nabla^2\psi = \frac{-2m}{h^2} \quad i\hbar\frac{\partial\psi}{\partial t} - V\psi$$

$$-\frac{\hbar^2}{2m}\nabla^2\psi = i\hbar\frac{\partial\psi}{\partial t} - V\psi$$

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = i\hbar\frac{\partial\psi}{\partial t}$$

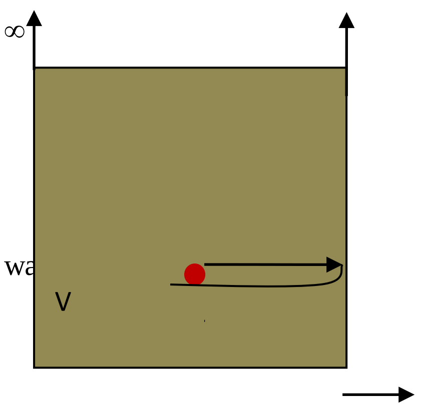
$$\left(-\frac{\hbar^2}{2m}\nabla^2 + V\right)\psi = i\hbar\frac{\partial\psi}{\partial t}$$

$$\boxed{H\psi = E\psi}$$

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + V\right) = H$$ (Hamiltonian operator)

$$i\hbar\frac{\partial\psi}{\partial t}$$ = E (Energy operator)

6. Calculate the eigen value and eigen function of a particle in one dimensional box by using Schrodinger equation.



Consider a particle mass is m.

It moves along x axis between two walls at x=0, x=a.

This particle is bouncing back and forth between the

Potential energy of the particle inside the box (V) = 0

Walls height is infinite. so the particle never comes out.

0 a The potential function is square well potential.

The potential function , $V(x) = 0 \; for \; 0 < x < a$

$$V(x) = \infty \; for \; 0 \geq x \geq a \,.$$

The wave function $\begin{aligned} \psi &= 0 \; for x \leq 0 \\ \psi &= 0 \; for x \geq a \end{aligned}$

Because the wave function zero at walls of the box.(particle cannot exist on the walls)

To find the ψ of the particle inside the box at the limit $x = 0 \,\&\, x = a$

Schrodinger wave equation in one dimension is $\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E - V)\psi = 0$

Here V = 0, $\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2} E\,\psi = 0$

$$\frac{2m}{\hbar^2} E = k^2 ; \frac{4\pi^2 2m}{h^2} E = k^2 or k^2 = \frac{8\pi^2 mE}{h^2}$$

$$\frac{d^2\psi}{dx^2} + k^2\,\psi = 0$$

The general solution of equ, $\psi(x) = A \sin kx + B \cos kx$

A,B are unknown constants. These are obtained by applying boundary conditions.

(i) $\psi = 0 at x = 0$

0 = A sin 0+B cos 0

B = 0

(ii) $\psi = 0 at x = a$

Asin ka = 0

∴ A = 0 or Asin ka=o

A $\neq 0 because B = 0$

∴ $\sin ka = 0$ if $ka = n\pi$

n= integer (1,2,3,4..) or $k = \frac{n\pi}{a}$

Squaring equ, $k^2 = \frac{n^2\pi^2}{a^2}$

W.K.T

$$\frac{n^2\pi^2}{a^2} = \frac{8\pi^2 mE}{h^2}$$

The energy of the particle E $E_n = \frac{n^2h^2}{8ma^2}$

$$\psi_n(x) = A \sin\frac{n\pi x}{a}$$

E_n= Eigen value ; ψ_n = Eigen function

Hence The energy of the particle is quantised(the particles are associated with discrete energy values).

The value of A can be determined by normalisation of wave function.

The probability density is $\psi * \psi$

$$\psi * \psi = A sin \frac{n\pi x}{a} \times A sin \frac{n\pi x}{a}$$

$\psi^* = \psi$ since wave function is real.

$$\psi * \psi = A^2 sin^2 \frac{n\pi x}{a}$$

The probability if finding the particle inside the box at the limit o to a,

$$\int_0^a \psi * \psi dx = 1$$

Substitute the value of $\psi * \psi$, $\int_0^a A^2 sin^2 \frac{n\pi x}{a} \; dx = 1$ -

$$A^2 \int_0^a \frac{1 - cos\frac{2n\pi x}{a}}{2} dx = 1$$

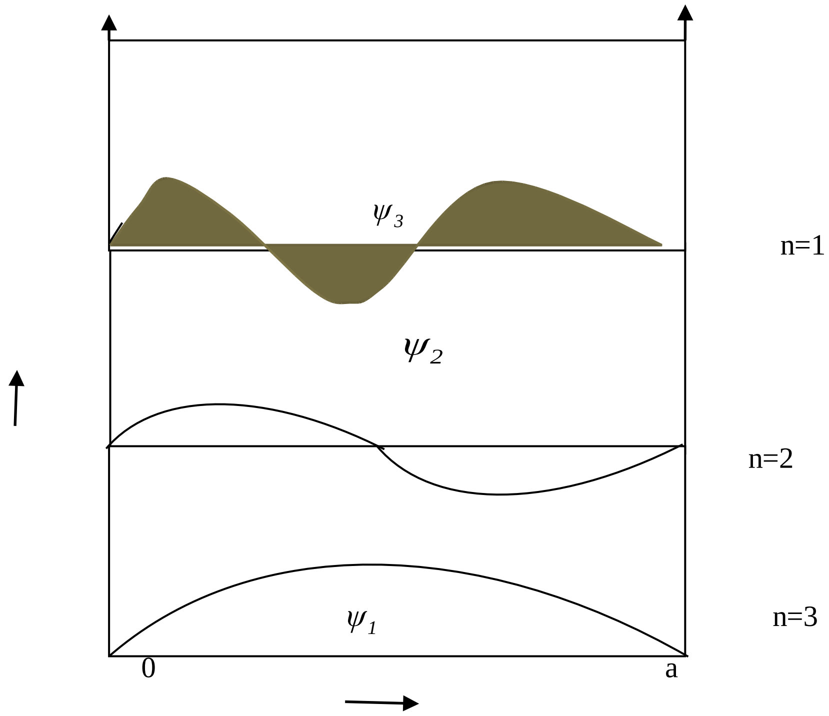
$$A^2 \int_0^a \frac{dx}{2} - \frac{1}{2} \int_0^a cos\frac{2n\pi x}{a} dx = 1$$

$$A^2 [\frac{x}{2} - \frac{1}{2} [\frac{sin\frac{2n\pi x}{a}}{\frac{2n\pi}{a}}]_o^a] = 1$$

$$A^2 [\frac{x}{2}]_0^a = 1$$

$(A^2a/2)=1$ or $A^2=2/a$ or

$$\psi_n = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a} \qquad\qquad A = \sqrt{\frac{2}{a}}$$



Case (i) for n=1

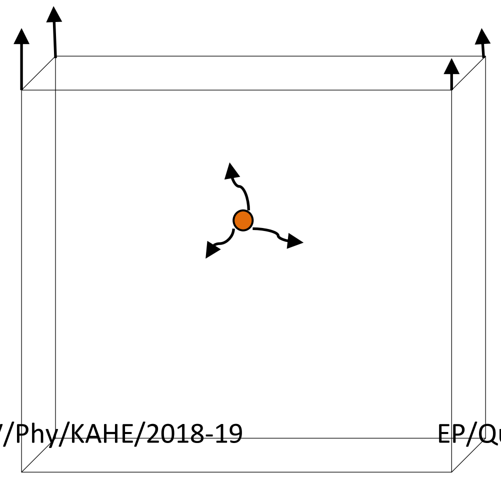
$$\psi_1 = \sqrt{\frac{2}{a}} \sin \frac{\pi x}{a} \qquad E_1 = \frac{h^2}{8ma^2}$$

Case (ii) for n=2

$$E_2 = \frac{4h^2}{8ma^2} = 4E_1$$

$$\psi_2 = \sqrt{\frac{2}{a}} \sin \frac{2\pi x}{a}$$

The solution of one dimensional potential well is extended to 3 dimensional potential box.Here the particle can move along three axis x, y, z.Consider a cube. All sides are equal in this case.



X

Z

$$E_{nx\,ny\,nz} = E_{nx} + E_{ny} + E_{nz}$$

$$E_{nx\,ny\,nz} = \frac{n^2h^2}{8ma^2} + \frac{n^2h^2}{8ma^2} + \frac{n^2h^2}{8ma^2}$$

$$E_{nx\,ny\,nz} = \frac{(n^2{}_x + n_y^2 + n_z^2)h^2}{8ma^2}$$

$$\psi_{nxnynz} = \psi_{nx}\psi_{ny}\psi_{nz}$$

$$= \sqrt{\frac{2}{a}}\sin\frac{n_x\pi x}{a}\sqrt{\frac{2}{a}}\sin\frac{n_y\pi x}{a}\sqrt{\frac{2}{a}}\sin\frac{n_z\pi x}{a}$$

$$\psi_{nxnynz} = \sqrt{\frac{8}{a^3}}\sin\frac{n_x\pi x}{a}\sin\frac{n_y\pi x}{a}\sin\frac{n_z\pi x}{a}$$

The combination of three quantum no's gives different eigen values and eigen functions.

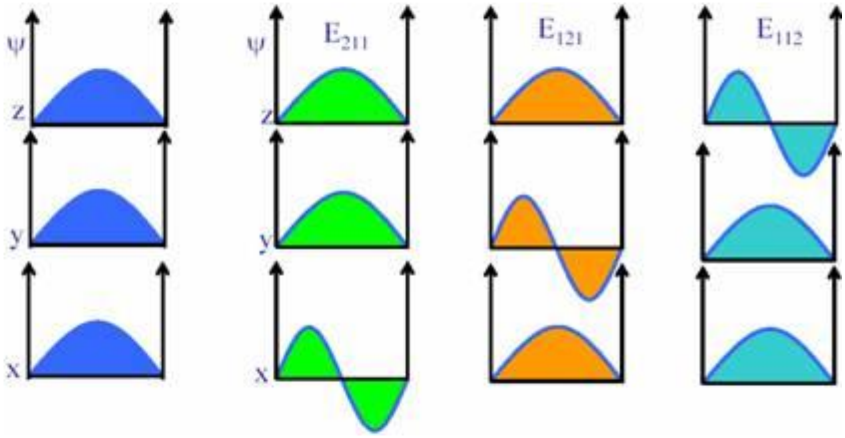
Example: If a state has quantum nos n_x=1, n_y=1, n_z=2

$E_{112} = \frac{6h^2}{8ma^2}$:Therefore eigen functions are

$$\psi_{112} = \sqrt{\frac{8}{a^3}}\sin\frac{\pi x}{a}\sin\frac{\pi x}{a}\sin\frac{2\pi x}{a}$$

$$\psi_{121} = \sqrt{\frac{8}{a^3}}\sin\frac{\pi x}{a}\sin\frac{2\pi x}{a}\sin\frac{\pi x}{a}$$

$$\psi_{211} = \sqrt{\frac{8}{a^3}}\sin\frac{2\ \pi x}{a}\sin\frac{\pi x}{a}\sin\frac{\pi x}{a}$$


ψ
z
y
x
ψ
E_{211}
z
y
x
E_{121}
E_{112}

UNIT- IV

APPLIED OPTICS.

Interference:

It is based on the super position principle which states that, when two (or) more light wave trains act simultaneously on any particle in a medium, the particle is displaced due to the superposition of all the wave trains.

Definition:

When two light waves from the sources superimposes on each other then the resultant amplitude in the region of superposition is different than the amplitude of the individual waves. This modification of light energy in change in amplitude is called as interference.

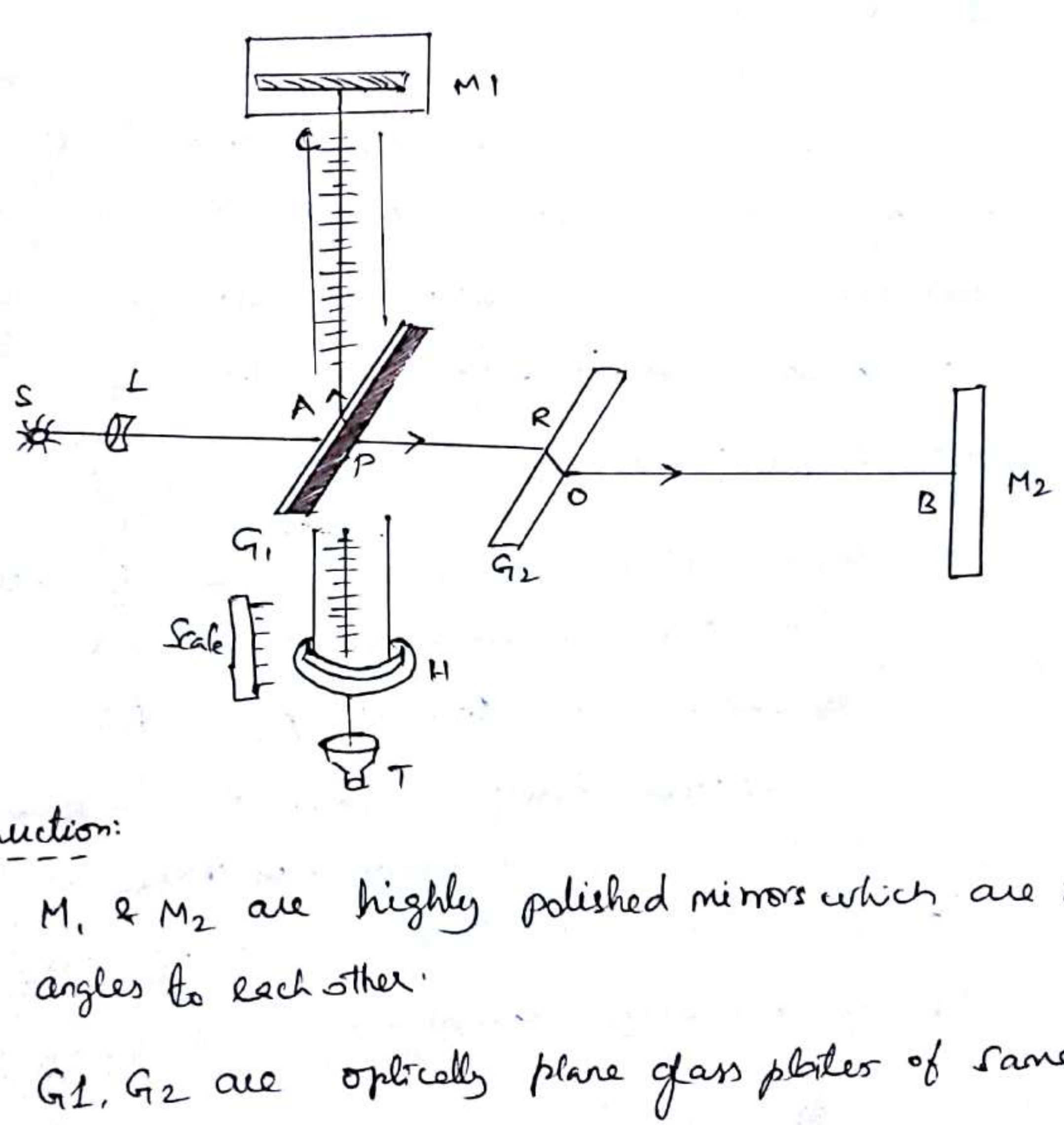
Conditions for interference

1. There must be two sources are coherent in nature (same frequency, amplitude, wavelength)
2. They should have constant phase difference.
3. The sources should be closer to each other and the distance between the sources and the screen must be larger.
4. For constructive interference: path difference $= n\lambda$
5. for destructive interference: path difference $= (2n+1)\lambda/2$

MICHELSON'S INTERFEROMETER AND TYPES OF FRINGES.

Principle:

The amplitude of light beam from a source is divided into two parts of equal intensities by partial reflection and transmission. These beams are then sent into two directions at right angles and are brought together after they suffer reflection from plane mirrors to produce interference fringes.



Construction:

→ M_1 & M_2 are highly polished mirrors which are right angles to each other.

→ G1, G_2 are optically plane glass plates of same thickness and placed parallel to each other.

→ G_1 and G_2 plates are inclined at an angle 45° with M_1 & M_2

Types of fringes:

(1) Circular fringes

When M_2 is exactly perpendicular to M_1 & the virtual image, mirror M_1' (image of M_2) an air film of constant thickness is enclosed between them.

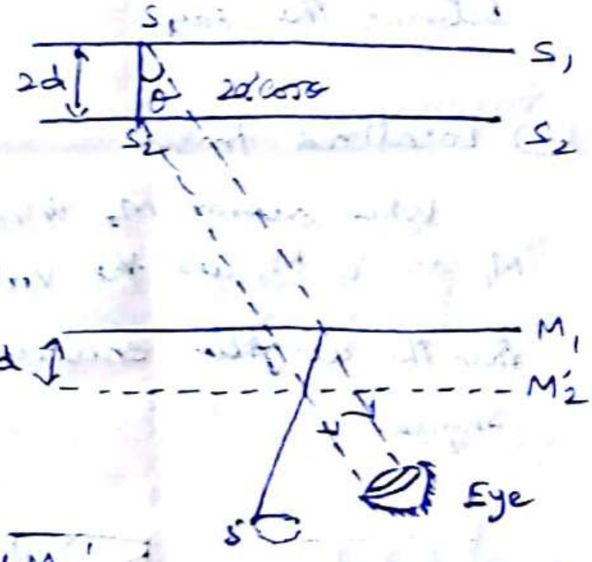
Air film gives reflected beam to interface.

The path difference depends upon the following factors.

(i) Separation between M_1 & M_2'

(ii) Angle subtended on the eye

(iii) inclination between M_1 and M_2'



path differences are different for different values of θ

$S \rightarrow$ Source

$S_1, S_2 \rightarrow$ Virtual source due to M_1 & M_2'.

If d is distance b/w M_1 & M_2'

then $2d$ is distance b/w S_1 & S_2.

path difference b/w two rays $= 2d\cos\theta$

$\lambda/2 \rightarrow$ is additional path difference (light reflected from mirror M_2 is again reflected by the semi-silvered glass plate G_1)

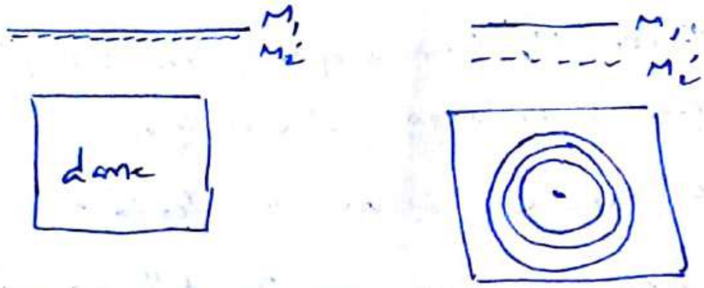
$\therefore$ Total path difference b/w two rays $= 2d\cos\theta + \lambda/2$

If the total path difference is $n\lambda$, $\Rightarrow$ we have bright fringes

If " " " $(2n+1)\frac{\lambda}{2} \Rightarrow$ " " dark fringes

Case (i).

when M_1 and M_2' Coincides, the path difference is zero therefore the field of view is perfectly dark.



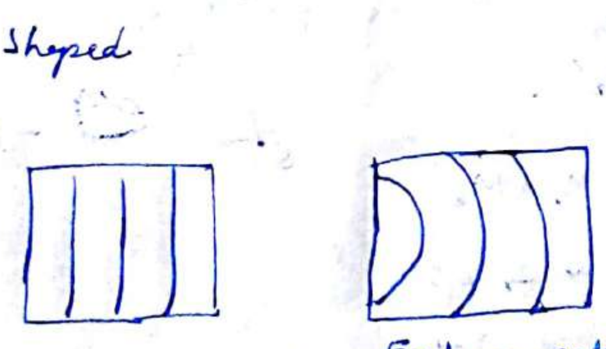
Case (ii)

when M_1 is moved either way parallel to itself, widely spaced circular fringes are produced.

Width of fringes depends upon the path difference between the rays.

(2) Localized fringes:

When mirror M_2 is not exactly perpendicular to M_1 (or) if M_1 and the virtual mirror M_2' are inclined, then the air film enclosed between them is wedge shaped



For small path difference

For Large path difference

(3) Localized whitelight fringes

with whitelight, the fringes are observed only when the path difference is very small. Central fringe is dark and other fringes are coloured.

Applications of Michelson interferometer

It is used to determine

1. wavelength of the monochromatic light
2. refractive index and thickness of the various thin transparent materials.
3. The difference b/w two neighbouring wavelengths

Determination of wavelength.

If n is the no. of fringes that crosses the centre of the field and 'd' is the distance through which the mirror is moved.

$$2d\cos\theta = n\lambda \text{ (bright)}$$

Since θ is very small $\theta \approx 0$

$$\therefore 2d = n\lambda$$

$$d = \frac{n\lambda}{2}, \; \lambda = \frac{2d}{n}$$

If $n=1$ (only one crosses the centre)

$$\therefore \lambda = 2d$$

Determination of thickness of a thin Transparent medium

In michelson interferometer Central fringe in the field of view is made to coincide with the vertical cross wire and the position of the mirror M_1 is noted.

Now the thin transparent sheet of known refractive index (μ) is introduced b/w the glass plate G_2 and the mirror M_2.

Due to new sheet introduction, a path difference is [illegible] and the central fringe is shifted from path difference is $2(\mu-1)t$.

$$2(\mu-1)t = n\lambda$$

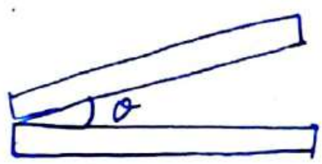
$$\lambda = \frac{2d}{n}$$

$$2(\mu-1)t = \frac{n\,2d}{n}$$

$$(\mu-1)t = d$$

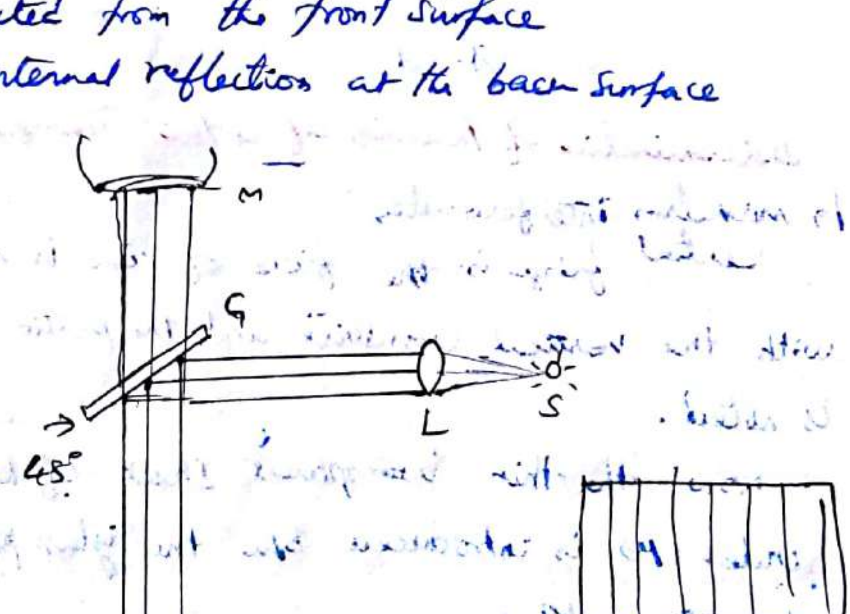
Thickness of thin sheet $t = \frac{d}{(\mu-1)}$

Airwedge & its applications



Two glass plates are inclined at an angle (θ) by introducing a thin material, forming a wedge shaped air film. This film is illuminated by sodium light.

Interference occurs between the two rays.
(i) Reflected from the front surface
(ii) by internal reflection at the back surface



Applications To find the thickness of material

$$t = \frac{\lambda L}{2\beta}$$

LASER

Introduction.

LASER stands for Light amplification by stimulated emission of radiation.

Laser is a device which emits a powerful, monochromatic collimated beam of light. The emitted light waves are coherent in nature.

Characteristics of Laser:

1. Directionality

Ordinary light spreads in all directions and its angular spread is 1m/m. But it is found that laser is highly directional and is angular spread is 1mm/m. For example, the laser beam can be focused to very long distance with a few divergence or angular spread.

Intensity:

Since an ordinary light spreads in all directions, the intensity reaching the target is very less. But in the case of laser, due to high directionality, the intensity of laser beam reaching the target is of high intense beam. For example, 1 mill watt power of He-Ne laser appears to be brighter than the sunlight.

2. Monochromatic:

Laser beam is highly monochromatic; the wavelength is single, whereas in ordinary light like mercury vapour lamp, many wavelengths of light are emitted.

4 Coherence:

It is an important characteristic of laser beam. In lasers the wave trains of same frequency are in phase, the radiation given out is in mutual agreement not only in phase but also in the direction of emission and polarization. Thus it is a coherent beam. Due to high coherence it results in an extremely high power.

2.1.3 Differences between ordinary light and Laser beam.

S.No	Ordinary light	Laser beams
1	In ordinary light the angular spread is more.	In laser beam the angular spread is less.
2	They are not directional.	They are highly directional.
3	It is less intense	It is highly intense
4	It is not a coherent beam and is not in phase.	It is a coherent beam and is in phase
5	The radiation are polychromatic	The radiations are monochromatic
6	Example: Sun light, Mercury vapor lamp	He- Ne Laser, Co_2 laser

Derive an expression for Einstein coefficients.

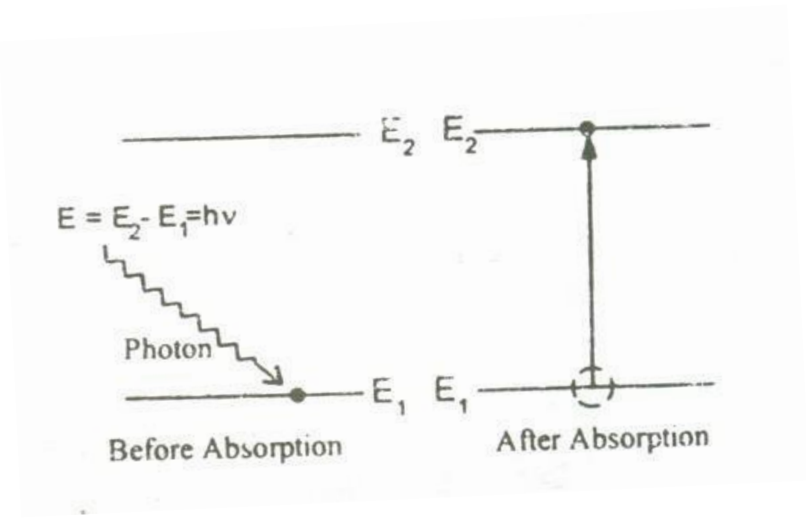
Different processes involved in optical beam emission

1. Induced or stimulated emission
2. Spontaneous emission
3. Stimulated emission

1. Stimulated absorption:

An atom in the lower energy level or ground state energy level E_1 absorbs the incident photon radiation of energy ν and goes to the higher energy level or excited level E_2 as shown in figure. This process is called absorption.

If there are many numbers of atoms in the ground state then each atom will absorb the energy



from the incident photon and goes to the excited state. Q is energy density of incident radiation.

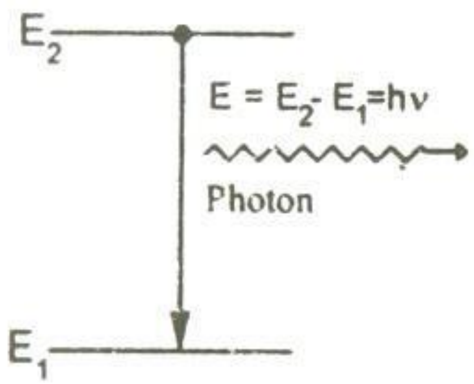
$$\begin{aligned} N_{ab} &\alpha\, N_1 Q \\ N_{ab} &= B_{12} N_1 Q \end{aligned} \quad \text{------------------(1)}$$

Where, B_{12} is proportionality constant.

2. Spontaneous emission:

The atom in the excited state returns to the ground state by emitting a photon of energy $E = (E_2 - E_1) = h\nu$

Spontaneously without any external triggering as shown in the figure.



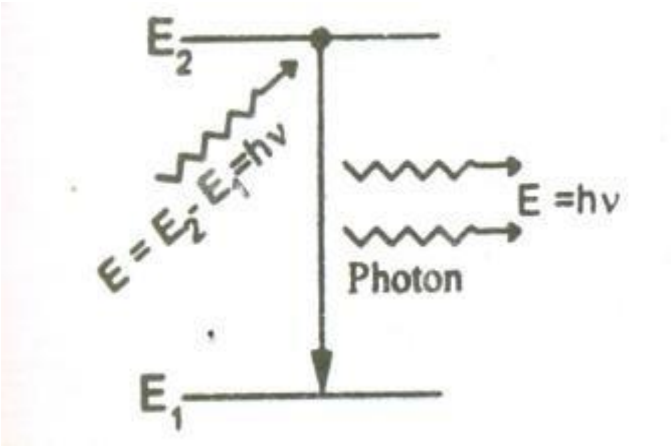
This process is known as spontaneous emission. Such an emission is random and is independent of incident radiation. If N_1 and N_2 are the numbers of atoms in the ground state (E_1) and excited state (E_2) respectively, then

$$\begin{aligned} N_{sp} &\alpha\, N_2 \\ N_{sp} &= A_{21} N_2 \end{aligned} \quad \text{----------------(2)}$$

Where, A_{21} is proportionality constant.

3. Stimulated Emission:

The atom in the excited state can also return to the ground state by external triggering or inducement of photon thereby emitting a photon of energy equal to the energy of the incident photon, known as stimulated emission. Thus results in two photons of same energy, phase difference and of same directionality as shown.



$$N_{st} \alpha N_2 Q$$
$$N_{st} = B_{21} N_2 Q$$

Where, B_{21} is proportionality constant.

A_{12}, B_{12} and B_{21} are known as Einstein's coefficients.

Under equilibrium condition,

$$N_{sp} + N_{st} = N_{ab} ----------(4)$$

Substitute 1,2 *and* 3 *in eqn.* 4

$$A_{21}N_2 + B_{21}N_2Q = B_{12}N_1Q -----(5)$$

Re *arranging eqn.* 5

$$B_{12}N_1Q - B_{21}N_2Q = A_{21}N_2$$

$$Q(B_{12}N_1 - B_{21}N_2) = A_{21}N_2$$

$$Q = \frac{A_{21}N_2}{B_{12}N_1 - B_{21}N_2} -----------(6)$$

dividing by $B_{21}N_2$

$$Q = \frac{\frac{A_{21}N_2}{B_{21}N_2}}{\frac{B_{12}N_1}{B_{21}N_2} - \frac{B_{21}N_2}{B_{21}N_2}}$$

$$Q = \frac{A_{21}}{B_{21}} \frac{1}{\left(\frac{B_{12}}{B_{21}}\right)\frac{N_1}{N_2} - 1} ---------(7)$$

on substituting $\frac{N_2}{N_2} = e^{\frac{h\upsilon}{kT}}$ *in eqn.* 7

$$Q = \frac{A_{21}}{B_{21}} \frac{1}{\left(\frac{B_{12}}{B_{21}}\right)e^{\frac{h\upsilon}{kT}} - 1} ---------(8)$$

Planck's radiation formula

$$Q = \frac{8\pi h\upsilon^3}{c^3} \frac{1}{e^{h\upsilon/kT} - 1} ---------(9)$$

comparing equation (8) *and* (9)

$$\left(\frac{B_{12}}{B_{21}}\right) = 1$$

$$B_{12} = B_{21} -------------(10)$$

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\upsilon^3}{c^3} -----------(11)$$

$B_{12} = B_{21}$ are Einstein coefficients.

CO2 Molecular gas laser

It was the first molecular gas laser developed by Indian born American scientist Prof.C.K.N.Pillai.

It is a four level laser and it operates at 10.6 μm in the far IR region. It is a very efficient laser.

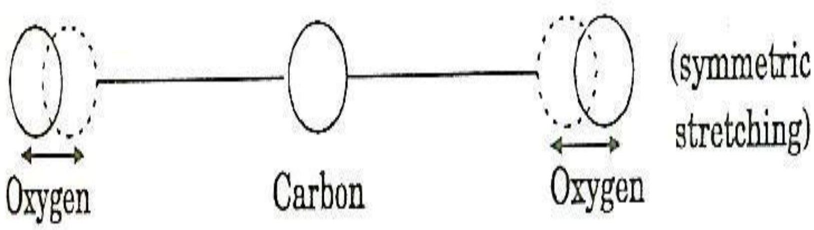
Energy states of CO_2 molecules.

A carbon dioxide molecule has a carbon atom at the center with two oxygen atoms attached, one at both sides. Such a molecule exhibits three independent modes of vibrations. They are

a) Symmetric stretching mode.
b) Bending mode
c) Asymmetric stretching mode.

a. Symmetric stretching mode

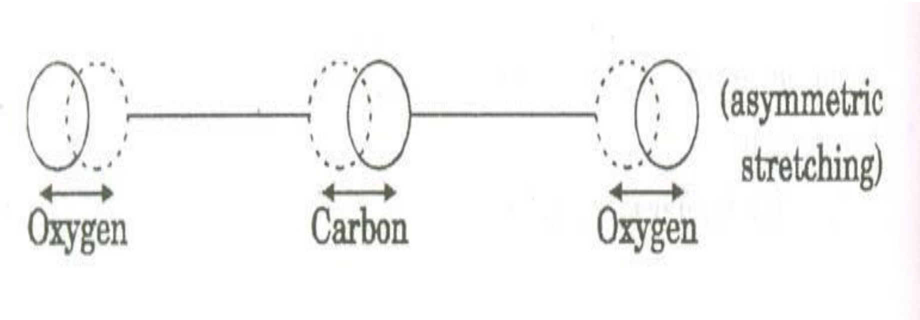
In this mode of vibration, carbon atoms are at rest and both oxygen atoms vibrate simultaneously along the axis of the molecule departing or approaching the fixed carbon atoms.



b. Bending mode:

In this mode of vibration, oxygen atoms and carbon atoms vibrate perpendicular to molecular axis.

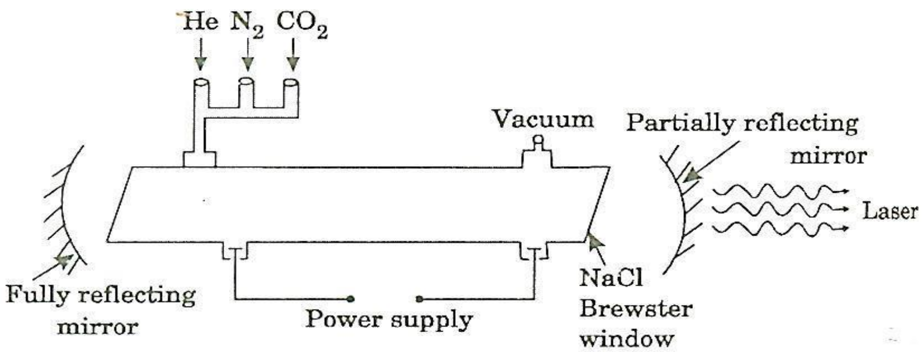
c. **Asymmetric stretching mode**:



In this mode of vibration, oxygen atoms and carbon atoms vibrate asymmetrically, i.e., oxygen atoms move in one direction while carbon atoms in the other direction.

Principle:

The active medium is a gas mixture of CO_2, N2 and He. The laser transition takes place between the vibrational states of CO_2 molecules.



Construction:

It consists of a quartz tube 5 m long and 2.5 cm in the diameter. This discharge tube is filled with gaseous mixture of CO_2 (active medium), helium and nitrogen with suitable partial pressures.

The terminals of the discharge tubes are connected to a D.C power supply. The ends of the discharge tube are fitted with NaCl Brewster windows so that the laser light generated will be polarized.

Two concave mirrors one fully reflecting and the other partially form an optical resonator.

Working:

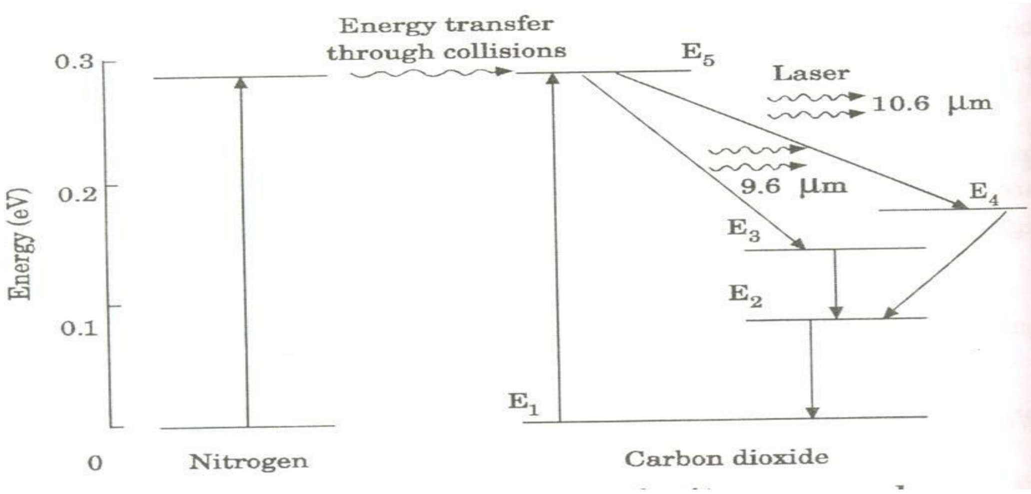


Figure shows energy levels of nitrogen and carbon dioxide molecules.

When an electric discharge occurs in the gas, the electrons collide with nitrogen molecules and they are raised to excited states. This process is represented by the equation

$$N_2 + e^* = N_2^* + e$$

N_2 = Nitrogen molecule in ground state e^* = electron with kinetic energy

N_2^* = nitrogen molecule in excited state e= same electron with lesser energy

Now N_2 molecules in the excited state collide with CO_2 atoms in ground state and excite to higher electronic, vibrational and rotational levels.

This process is

represented by the

equation $N_2^* +$

$CO_2 = CO_2^* + N_2$

N_2^* = Nitrogen molecule in excited state. CO_2 = Carbon dioxide atoms in ground state CO_2^* = Carbon dioxide atoms in excited state N_2 = Nitrogen molecule in ground state.

Since the excited level of nitrogen is very close to the E_5 level of CO_2 atom, population in E_5 level increases.

As soon as population inversion is reached, any of the spontaneously emitted photon will trigger laser action in the tube. There are two types of laser transition possible.

I. **Transition E_5 to E_4 :**

This will produce a laser beam of wavelength 10.6µm

II. Transition E_5 to E_3

This transition will produce a laser beam of wavelength 9.6µm. Normally 10.6µm transition is more intense than 9.6µm transition. The power output from this laser is 10kW.

Characteristics:

1. Type: It is a molecular gas laser.
2. Active medium: A mixture of CO_2 , N_2 and helium or water vapour is used as active medium
3. Pumping method: Electrical discharge method is used for Pumping action
4. Optical resonator: Two concave mirrors form a resonant cavity
5. Power output: The power output from this laser is about 10kW.
6. Nature of output: The nature of output may be continuous

wave or pulsed wave.

7. Wavelength of output: The wavelength of output is 0.6μm and 10.6μm.

Advantages:

1. The construction of CO_2 laser is simple
2. The output of this laser is continuous.
3. It has high efficiency
4. It has very high output power.
5. The output power can be increased by extending the length of the gas tube.

Disadvantages:

1. The contamination of oxygen by carbon monoxide will have some effect on laser action
2. The operating temperature plays an important role in determining the output power of laser.
3. The corrosion may occur at the reflecting plates.
4. Accidental exposure may damage our eyes, since it is invisible (infra red region) to our eyes.

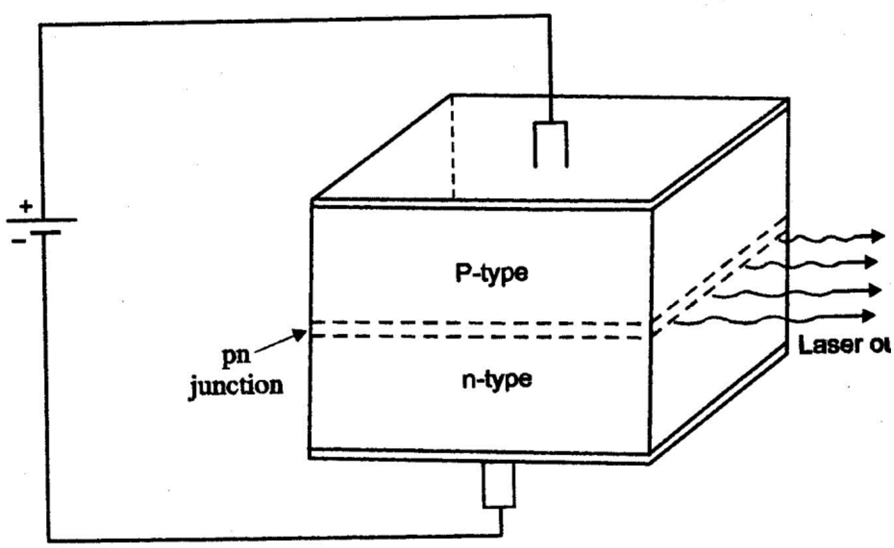
Applications:

1. High power CO_2 laser finds applications in material processing, welding, drilling, cutting soldering etc.
2. The low atmospheric attenuation (10.6μm makes CO_2 laser suitable for open air communication.
3. It is used for remote sensing
4. It is used for treatment of liver and lung diseases.
5. It is mostly used in neuro surgery and general surgery.
6. It is used to perform microsurgery and bloodless operations.

6. Explain the construction and working of Homo-junction semiconductor diode laser

Principle:

When a p-n junction diode is forward biased, the electrons from n – region and the holes from the p- region cross the junction and recombine with each other. During the recombination process, the light radiation (photons) is released from a certain specified direct band gap semiconductors like Ga-As. This light radiation is known as recombination radiation. The photon emitted during recombination stimulates other electrons and holes to recombine. As a result, stimulated emission takes place which produces laser.



Construction:

Figure shows the basic construction of semiconductor laser. The active medium is a p-n junction diode made from the single crystal of gallium arsenide. This crystal is cut in the form of a platter having thickness of 0.5μmm.

The platelet consists of two parts having an electron conductivity (n-type) and hole conductivity (p-type).

The photon emission is stimulated in a very thin layer of PN junction (in order of few microns). The electrical voltage is applied to the crystal through the electrode fixed on the upper surface.

The end faces of the junction diode are well polished and parallel to each other. They act as an optical resonator through which the emitted light comes out.

When the PN junction is forward biased with large applied voltage, the electrons and holes are injected into junction region in considerable concentration

The region around the junction contains a large amount of electrons in the conduction band and a large amount of holes in the valence band.

If the population density is high, a condition of population inversion is achieved. The electrons and holes recombine with each other and this recombination's produce radiation in the form of light.

When the forward – biased voltage is increased, more and more light photons are emitted and the light production instantly becomes stronger. These photons will trigger a chain of stimulated recombination resulting in the release of photons in phase.

The photons moving at the plane of the junction travels back and forth by reflection between two sides placed parallel and opposite to each other and grow in strength. After gaining enough strength, it gives out the laser beam of wavelength 840 nm.

Characteristics:

1. **Type**: It is a solid state semiconductor laser.
2. **Active medium**: A PN junction diode made from single crystal of gallium arsenide is used as an active medium.
3. **Pumping method**: The direct conversion method is used for pumping action
4. **Power output:** The power output from this laser is 1mW.
5. **Nature of output:** The nature of output is continuous wave or pulsed output.
6. **Wavelength of Output:** gallium arsenide laser gives infrared radiation wavelength 830 to 850 nm.

Advantages:

1. I t is very small in dimension. The arrangement is simple and compact.
2. It exhibits high efficiency.
3. The laser output can be easily increased by controlling the junction current
4. It is operated with lesser power than ruby and CO_2 laser.
5. It requires very little auxiliary equipment
6. It can have a continuous wave output or pulsed output.

Disadvantages:

1. It is difficult to control the mode pattern and mode structure of laser.
2. The output is usually from 5 degree to 15 degree i.e., laser beam has large

divergence.

3. The purity and monochromacity are power than other types of laser
4. Threshold current density is very large (400A/mm^2).
5. It has poor coherence and poor stability.

Application:

1. It is widely used in fiber optic communication
2. It is used to heal the wounds by infrared radiation
3. It is also used as a pain killer
4. It is used in laser printers and CD writing and reading.

7. Explain the construction and working of hetero-junction semiconductor diode laser

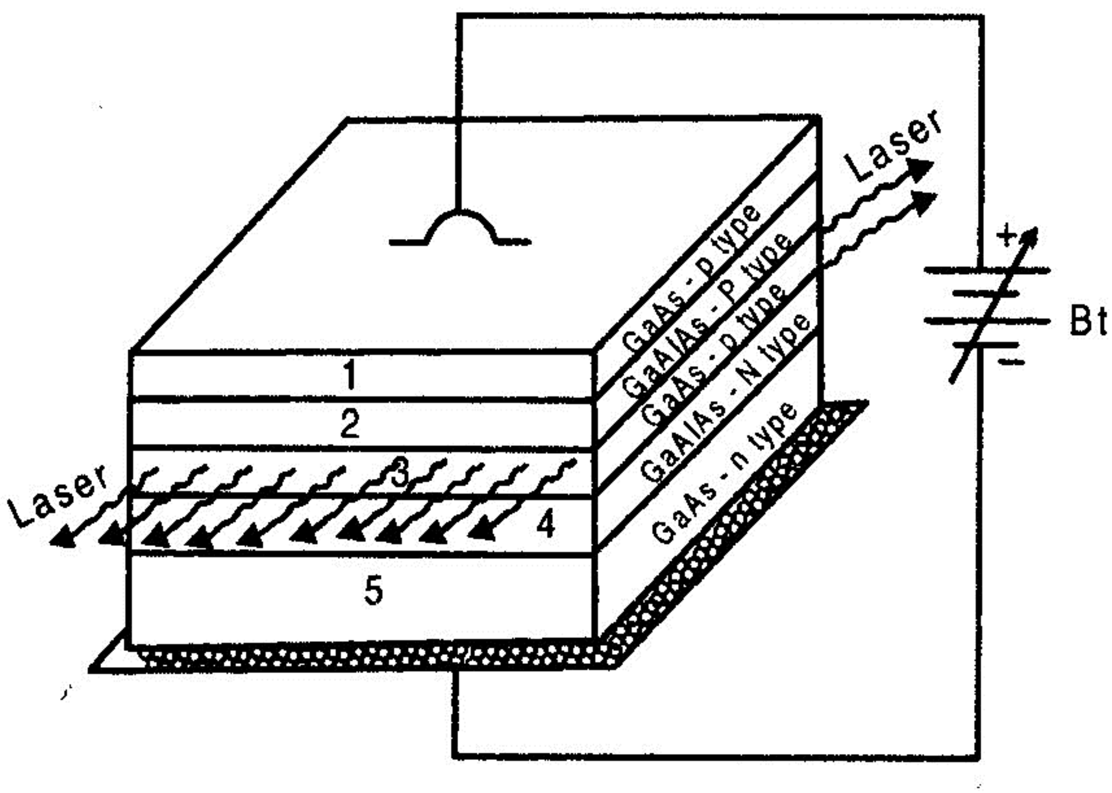
A pn junction made up of the different materials in two regions ie., n type and p type is known ad hetrojunction.

Principle:

When a PN junction diode is forward biased, the electrons from the n region and holes from the p region recombine with each other at the junction. During recombination process, light is released from certain specified direct band gap semiconductors.

A layer of Ga-As p – type (3rd layer) will act as the active region. This layer is sand witched between two layers having wider band gap viz GaAlAs-p – type (2nd layer) and **GaAlAs**-n- type (4th layer).

The end faces of the junctions of 3rd and 4th layer are well polished and parallel to each other. They act as an optical resonator.



Working:

When the PN junction is forward biased, the electrons and holes are injected into the junction region. The region around the junction contains large amount of electrons in the conduction band and holes in the valence band.

Thus the population inversion is achieved. At this stage, some of the injected charge carriers recombines and produce radiation in the form of light.

When the forward biased voltage is increased, more and more light photons are emitted and the light intensity is more. These photons can trigger a chain of stimulated recombination's resulting in the release of photons in phase.

The photons moving at the plane of the junction travels back and forth by reflection between

two sides and grow its strength. A coherent beam of laser having wavelength nearly 8000 out

from the junction region.

S.No	TITLE		Description

1.	Type	:	It is a heterojunction semiconductor laser
2.	Active medium	:	PN junctions made from different layers.
3.	Pumping method	:	Direct conversion method
4.	Power output	:	The power output of laser beam is 1 mW
5.	Nature of the Output	:	Continuous wave form
6.	Wavelength of the output	:	Nearly 8000 $\overset{0}{A}$

Advantages:

1. It produces continuous wave output.
2. The power output is very high.

Disadvantages:

1. It is very difficult to grow different layers of PN junction.
2. The cost is very high.

Applications:

1. This type of laser is mostly used in optical applications
2. It is widely used in computers, especially on CD-ROMs.

APPLICATIONS OF LASER

The most significant applications of lasers include:

- Lasers in medicine
- Lasers in communications
- Lasers in industries
- Lasers in science and technology
- Lasers in military

Lasers in Medicine

1. Lasers are used for bloodless surgery.

2. Lasers are used to destroy kidney stones.
3. Lasers are used in cancer diagnosis and therapy.
4. Lasers are used for eye lens curvature corrections.
5. Lasers are used in fiber-optic endoscope to detect ulcers in the intestines.
6. The liver and lung diseases could be treated by using lasers.
7. Lasers are used to study the internal structure of microorganisms and cells.
8. Lasers are used to produce chemical reactions.
9. Lasers are used to create plasma.
10. Lasers are used to remove tumors successfully.
11. Lasers are used to remove the caries or decayed portion of the teeth.
12. Lasers are used in cosmetic treatments such as acne treatment, cellulite and hair removal.

Lasers in Communications

1. Laser light is used in optical fiber communications to send information over large distances with low loss.
2. Laser light is used in underwater communication networks.
3. Lasers are used in space communication, radars and satellites.

Lasers in Industries

1. Lasers are used to cut glass and quartz.
2. Lasers are used in electronic industries for trimming the components of Integrated Circuits (ICs).
3. Lasers are used for heat treatment in the automotive industry.

4. Laser light is used to collect the information about the prefixed prices of various products in shops and business establishments from the bar code printed on the product.
5. Ultraviolet lasers are used in the semiconductor industries for photolithography. Photolithography is the method used for manufacturing printed circuit board (PCB) and microprocessor by using ultraviolet light.
6. Lasers are used to drill aerosol nozzles and control orifices within the required precision.

Lasers in Science and Technology

1. A laser helps in studying the Brownian motion of particles.
2. With the help of a helium-neon laser, it was proved that the velocity of light is same in all directions.
3. With the help of a laser, it is possible to count the number of atoms in a substance.
4. Lasers are used in computers to retrieve stored information from a Compact Disc (CD).
5. Lasers are used to store large amount of information or data in CD-ROM.
6. Lasers are used to measure the pollutant gases and other contaminants of the atmosphere.
7. Lasers helps in determining the rate of rotation of the earth accurately.
8. Lasers are used in computer printers.
9. Lasers are used for producing three-dimensional pictures in space without the use of lens.
10. Lasers are used for detecting earthquakes and underwater nuclear blasts.

11. A gallium arsenide diode laser can be used to setup an invisible fence to protect an area.

Lasers in Military

1. Laser range finders are used to determine the distance to an object.
2. The ring laser gyroscope is used for sensing and measuring very small angle of rotation of the moving objects.
3. Lasers can be used as a secretive illuminators for reconnaissance during night with high precision.
4. Lasers are used to dispose the energy of a warhead by damaging the missile.
5. Laser light is used in LIDAR’s to accurately measure the distance to an object.

FIBER OPTICS

An optical fibre is made up of three concentric parts.

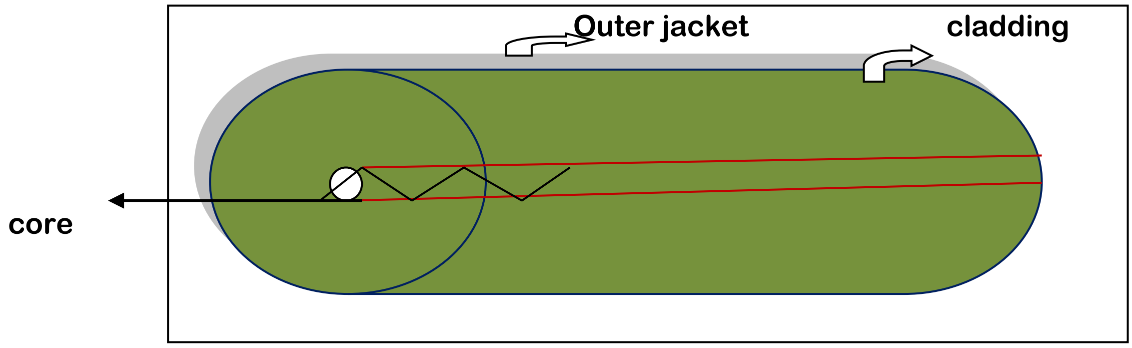
Core :

(made of glass i. e silicon dioxide or plastic)- Thin centre of the fiber . The light will travel through it. It has high refractive index.

Cladding:

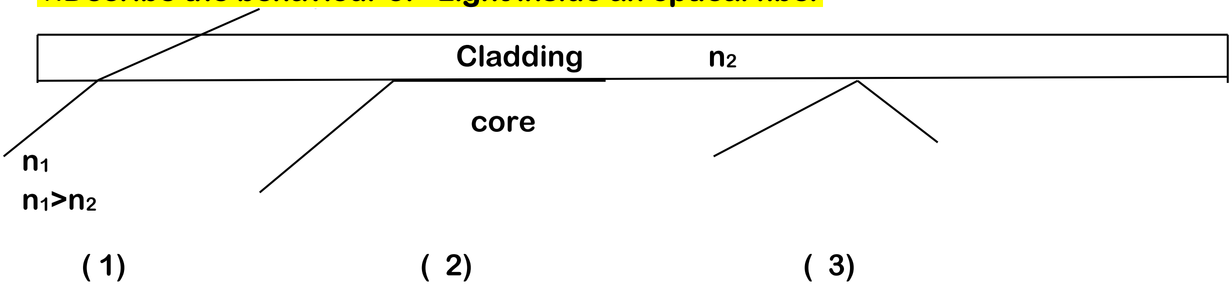
(made of glass plastic) - Material surrounding the core. It reflects the incident light. It has low refractive index than core

Jacket : Outer cover to product the fiber from damage.



Optical fiber

1.Decribe the behaviour of Light inside an optical fiber



Total internal reflection: When the angle of incidence exceeds the critical angle the incident ray is reflected in the same medium. This phenomenon is called total internal reflection.

Critical angle: When light travels from denser medium to rarer medium at a particular angle of incidence angle called the critical angle, the ray emerges along the surface of separation.

Case 1: When $\theta_1<\theta_c$,The light will refract through cladding.

Case 2: When $\theta_1= \theta_c$,The light will travel along the surface between core and cladding.

Case3: When $\theta_1 > \theta_c$,The light will be reflected totally

Expression for critical angle.

It is derived from snell's law $n_1 \sin\theta_1 = n_1 \sin\theta_2$

For total internal reflection

$$\theta_1 = \theta_c \quad \text{and} \quad \theta_2 = 90^\circ$$

$$n_1 \sin\theta_c = n_2 \sin 90^\circ$$

$$\sin\theta_c = (n_2/n_1)\sin 90^\circ$$

$$\sin\theta_c = (n_2/n_1) \quad \text{or}$$

$$\theta_c = \sin^{-1}(n_2/n_1)$$

Conditions for total internal reflection:

Light should travel from denser medium to rarer medium.

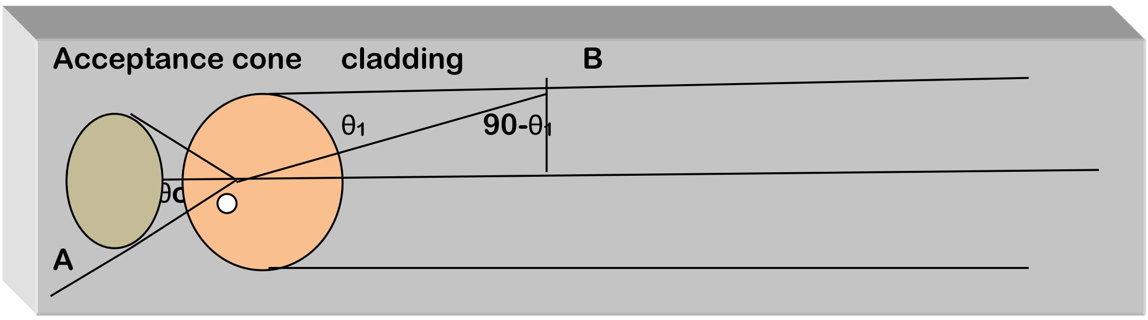
The angle of incidence on core should be greater than the critical angle.

The refractive index of the core should be greater than the refractive index of cladding.

2. Derive an expression for numerical aperture and acceptance angle.

Acceptance angle: The maximum angle with which a ray of light can enter through one end of the fiber and still be total internally reflected is called acceptance angle.

Numerical aperture: The sine of acceptance angle is known as numerical aperture. It shows the light collecting efficiency of fiber.



The incident light AO enters into an optical fiber. Here θ_1 is refracted angle in the core and θ_0 is light entering angle into the fiber.

If a light ray enter into fiber at an angle of incidence less than θ_0,The light will undergo the total internal reflection .Here the angle of incidence is more than critical angle.

Where n_1 is the refractive index of core ,

n_2 is the refractive index of cladding and

n_0 is refractive index of air.

Applying snell's law

$$n_0 \sin \theta_0 = n_1 \sin \theta_1$$

$$\sin \theta_0 = (n_1 / n_0) \sin \theta_1$$

$$\sin \theta_0 = (n_1 / n_0) \sqrt{1-\cos^2 \theta_1}$$

At the point B on the incidence of core and cladding

$$\theta_c = 90 - \theta_1$$

Applying snell's law

$$n_1 \sin(90^\circ - \theta_1) = n_2 \sin 90^\circ \quad \text{or}$$

$$n_1 \cos \theta_1 = n_2$$

$$\cos \theta_1 = n_2 / n_1$$

$$\sin \theta_0 = (n_1/n_0) \sqrt{1-(n_2^2/n_1^2)}$$

$$\sin \theta_0 = (n_1/n_0) \sqrt{(n_1^2-n_2^2)/n_1^2}$$

$$\sin \theta_0 = \sqrt{(n_1^2-n_2^2)}/n_0$$

$$\theta_0 = \sin^{-1}\sqrt{(n_1^2-n_2^2)}/n_0 \quad \text{or}$$

Refractive index of air (n_0) = 1

$$\theta_0 = \sin^{-1}\sqrt{(n_1^2-n_2^2)}$$

θ_0 - is called Acceptance angle

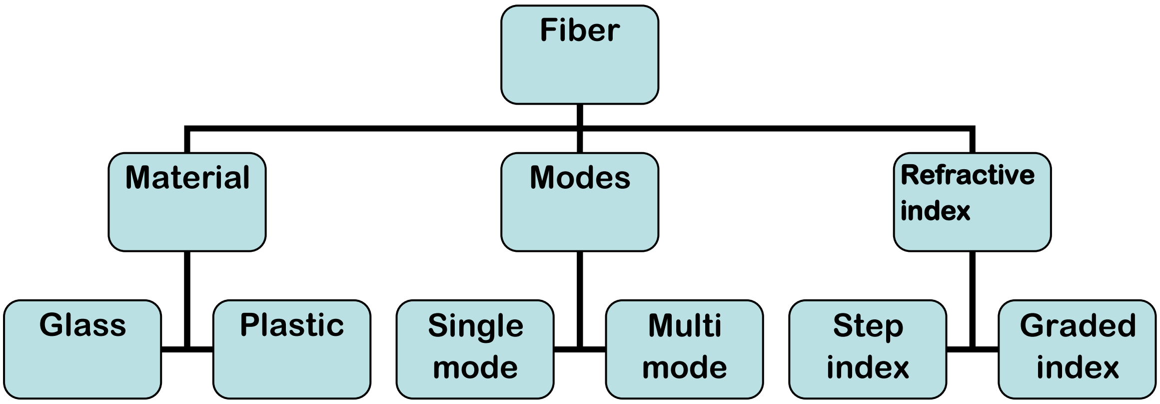
Numerical Aperture:

It is simply denoted as NA.

$$NA = \sin \theta_0$$

$$NA = \sin(\sin^{-1}\sqrt{(n_1^2-n_2^2)}) = \sqrt{(n_1^2-n_2^2)}$$

4.Discuss various types of optical fibers



On the basis of materials the fibers can be classified into two types. i.e Glass and Plastic .

Glass fiber is made up of fusing mixture of silica and oxides.

Ex. Core- SiO_2 , Cladding – P_2O_3–SiO_2.

Plastic fiber is made up of Plastics.

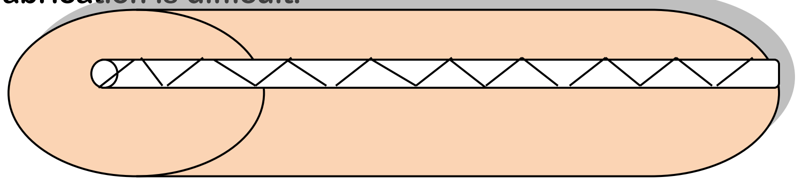
Ex. Core – Polystyrene , Cladding – Methyl Metha crylates .

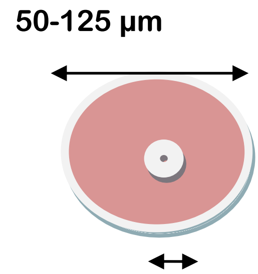
On the basis of Modes the fiber can be classified into two types. i.e Single mode and Multimode

In **single mode** only one mode is sent through the fiber.This kind of fiber core has small diameter.

There is a small refractive index difference between core and cladding

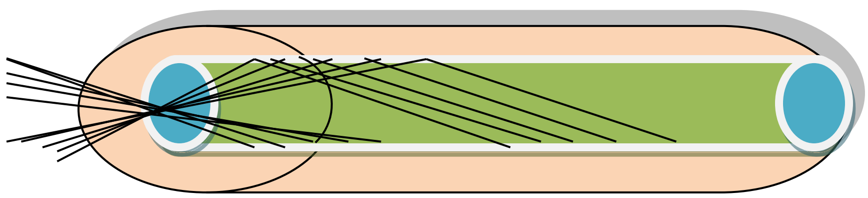
Laser diodes are used here. No dispersion in this case. Cost is high Because fabrication is difficult.

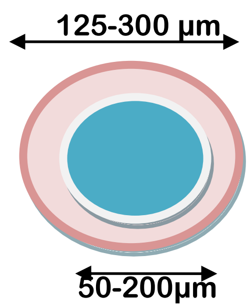




In **multi mode** many mode is sent through the fiber.

This fiber has large core diameter. Multi mode dispersion is here. Cost is low.





On the basis of refractive index the fiber is classified into two types. i.e step index and graded index.

In step index fiber is categorised into two types as single mode and multi mode.

Step index single mode fiber:

It has small core diameter and Numerical aperture.

It provides only one mode.

Laser diodes are used to signal transmission.

It is mainly used for Long distance communication and submarine systems.

Step index multi mode fiber:

It has Large core diameter and High numerical aperture.

Many mode is accepted here.

Bandwidth is low.

LED's are used.

Widely used in low bandwidth required data links.

Graded index multi mode fiber:

Here, The refractive index is maximum in core and gradually decreases towards the interface of core & cladding.

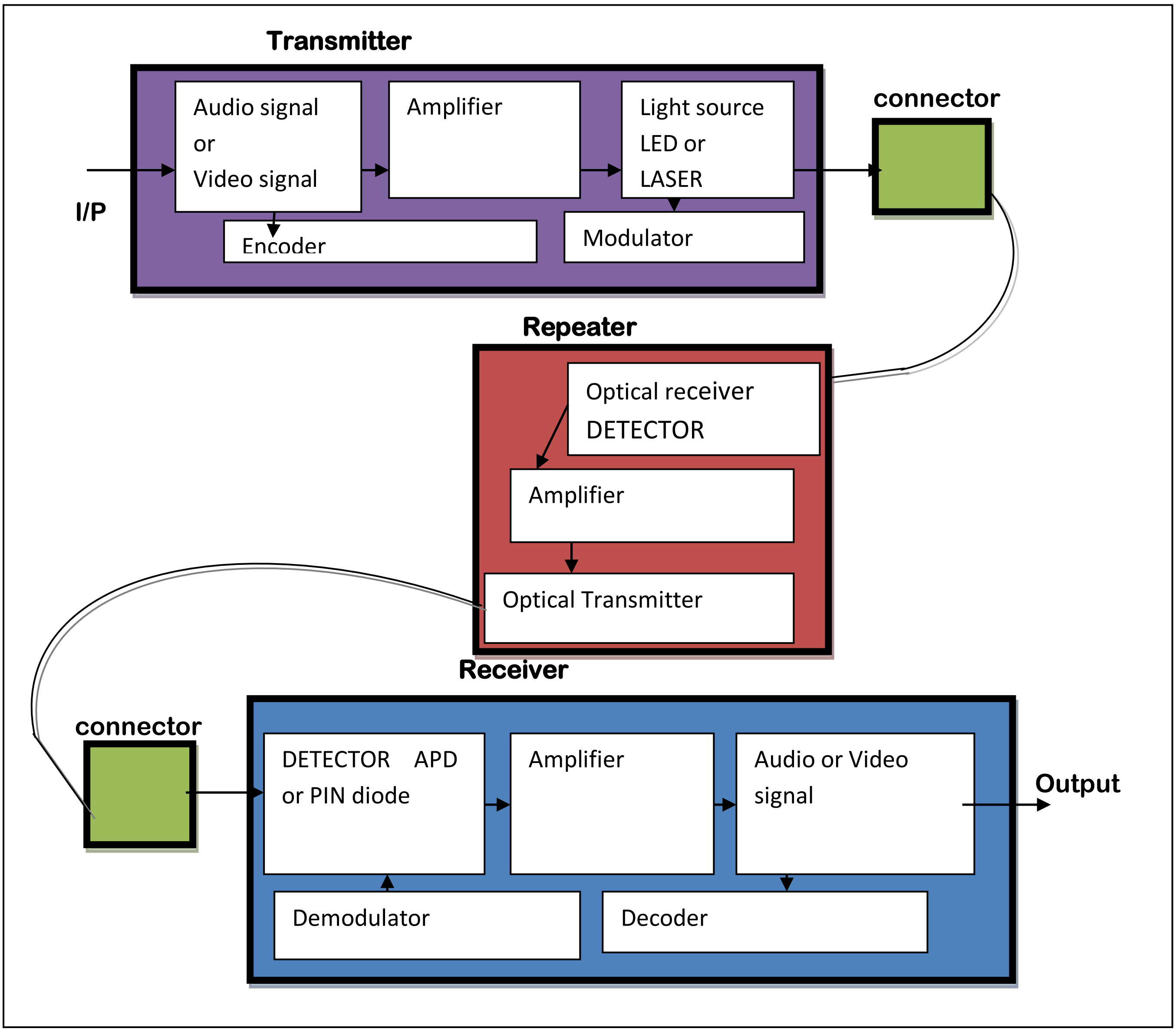
Core diameter is high.

Dispersion loss is minimised.

It has medium level band width.

Numerical aperture is low.LED or laser is used here.

5. Describe the optical fiber communication in detail with a neat diagram.



The main parts of the fiber optic communication system are

1.Information source

{Audio or Video signal}

2.Transmitter

{Light source, Encoder, Amplifier , Modulator}

3.Guiding medium (optical fiber)

4.Repeater

{Detector , Amplifier, Optical Source}

5.Receiver

{Detector, Demodulator, Decoder,Amplifier}

6.Receiving end

The information signal source may be voice, music or in any form. Here it is analog.

Transmitter consists of a encode , Amplifier ,Light source ,Modulator.

Encoder is to convert the analog into digital signal.

Light source may be LED or Laser. It converts Digital pulses into optical pulses.

Optical Fiber is used as Guiding media. It conducts signal by making total internal reflection.

Connector is used to couple the Transmitter and Fiber.

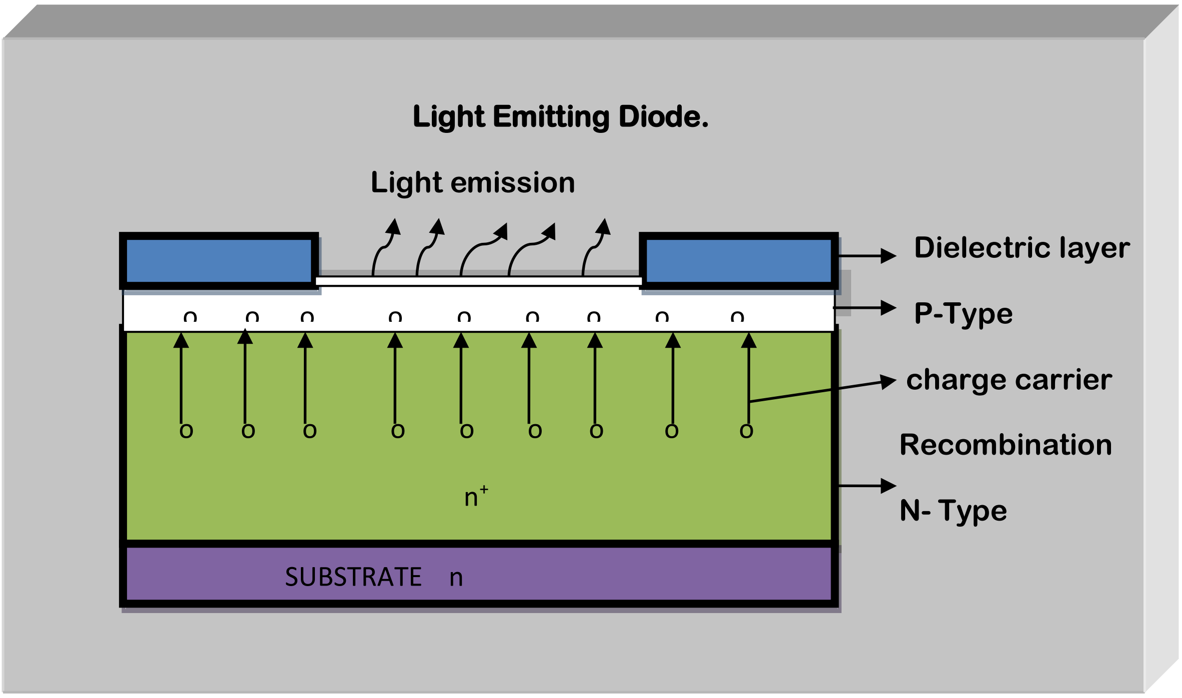
Repeater block is added to Produce degraded less signal.

Receiver consists of Decoder, Demodulator, Amplifier.

Decoder is to convert the digital into analog signal.

Finally one can receive the same signal at receiving end as given as input.

6. Describe the construction and working of an optical source.



- It converts electrical energy into optical energy.
- A N- type layer is formed on a substrate.A P-type layer is deposited on it by diffusion.
- The bottom of the substrate is coated with gold film for reflection.
- It is a semiconductor device. It emits light When it is connected in forward bias.
- In forward bias depletion layer width is reduced , raising the potential energy on the N- side and reducing that on the P-side.
- Photon emission takes place when the recombination of holes and electrons.
- There are three stage in LED process.
- Excitation or injection - Energy of carriers is raised by forward bias.
- Recombination - Most of the carriers give up their excess energy as photons.
- Extraction – Generated Photons leave from the semiconductor with desired optical stimulus.

Advantages:

- Small in size
- Light intensity is controlled by varying the current.
- It is rugged. Hence we can use easily.
- It can operate over a wide range of temperature.
- ON- OFF is easy.
- It is available in different colours.
- Low voltage is enough for its operation.
- Brightness is sufficient.

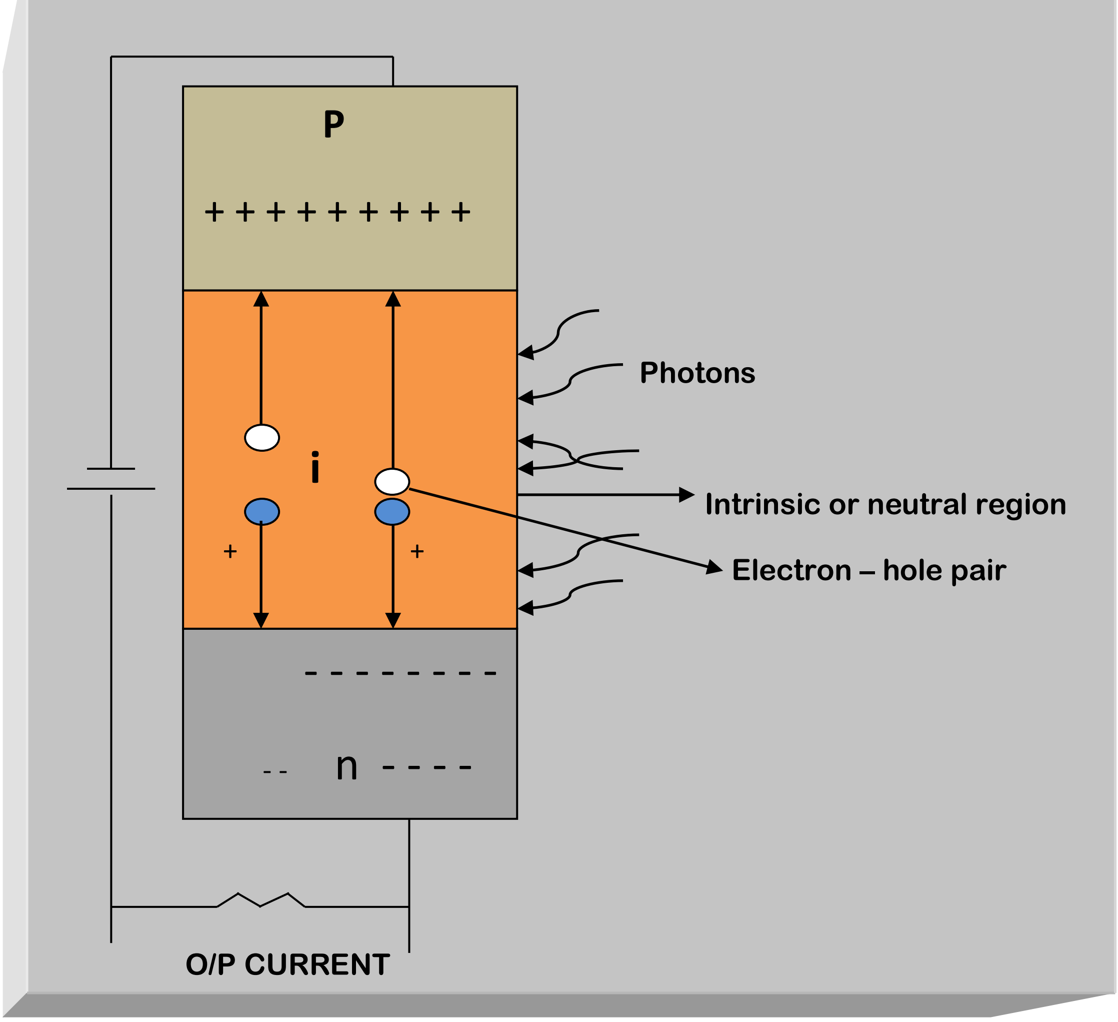
Disadvantages:

- It is not suited for large area display.
- It doesn't have any special Characters like LASER.

7. Describe the construction and working of Detectors.

It converts optical energy into electrical energy. On the basis of electrical energy required the detectors are classified as follows.PIN Diode, Avalanche photo diode (APD).

PIN PHOTO DIODE



Positive – intrinsic – negative diode. (PIN)

I – region is neutral.

P and n regions are heavily doped.

Here the i region is lightly doped with n type material.

I region is made as large as possible to receive large no. of photons.

It works in Reverse bias.

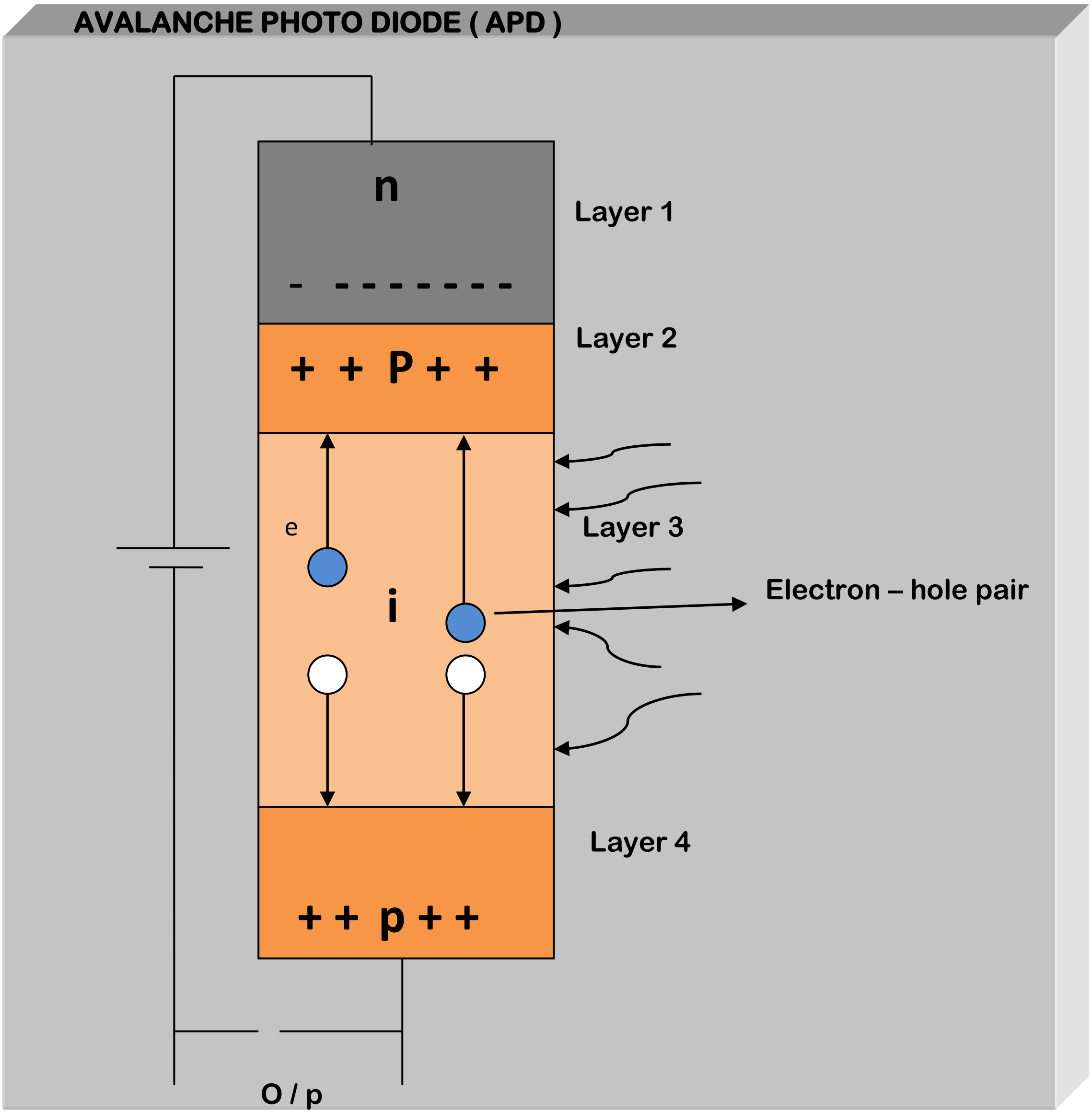
When light is illuminated the electron hole pairs are generated.

These pairs are accelerated by applied electric field.

Due to reverse bias the i – region gets widen.

When the incident photon energy equal to greater than band gap energy of   diode, the electron – hole pairs are formed by absorbing photons energy.

The generated photo current is directly proportional to the applied optical power.



It is a more sensitive device. Here large amount of electron – hole pairs are generated due to High reverse voltage is applied .

- Electron – hole pairs gain energy from high field and colloid with valence band electrons. This process multiplies the charge carriers in number. This is known as Avalanche effect.
- It consists of four layers. i.e n – p – i - p layers. It has a design as like p – n diode .Instead of single p, it has 2 p- regions and 1 intrinsic region.
- The two p- regions and n- region are heavily doped.The intrinsic region is lightly doped with P.Due to reverse bias, the intrinsic region gets widen. Photons are illuminated on i – region. This produces electron – hole pairs.

Crystal Physics – Unit 5

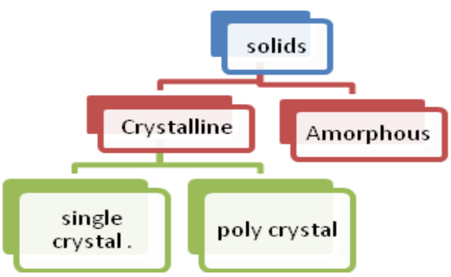
Formula

S.No	Description
1.	$Packingfactor = \frac{Volume\ occupied\ by\ the\ total\ no.ofatoms/unitcell}{Total\ volume\ of\ the\ unitcell} = \frac{v}{V}$
2.	Atomic radius of simple cubic crystal r = a/2
3.	Atomic radius of body centred cubic $r = \frac{\sqrt{3}a}{4}$
4.	Atomic radius of Face centred cubic $r = \frac{a\sqrt{2}}{4}$
5.	Atomic radius of Hexagonal closely packed structure r = a/2
7.	Atomic radius of Diamond structure atomic radius **r = a√3/8**
8.	Inter-planar distance $d = \frac{a}{\sqrt{(h^2+k^2+l^2)}}$

Part- A

1. **Classify the materials in terms of structure.**

Solids are broadly classified into two types based on the atomic structures.



- Crystal – Atoms or molecules are arranged in regular fashion throughout the crystal. ex-Ag, cu, Pt, Au, Ge, Cd, Fe
- Amorphous - Atoms or molecules are arranged in irregular pattern throughout the crystal. ex- Rubber, plastics, glass.

2. **What is a space lattice?**

Lattice is defined as an array of imaginary points. It represents the location of atoms or molecules. Every lattice point is identical in all respects. A three dimensional collection of points in space are called space lattice.

3. **What is basis?**

A crystal structure associated an assembly of atoms or molecules with every lattice point.This unit assembly is called basis.

Lattice+ Basis = crystal structure.

4. **Define lattice planes.**

A set of parallel and equally spaced planes in a space lattice formed w.r.t the lattice points is called lattice planes.

5. Define unit cell.

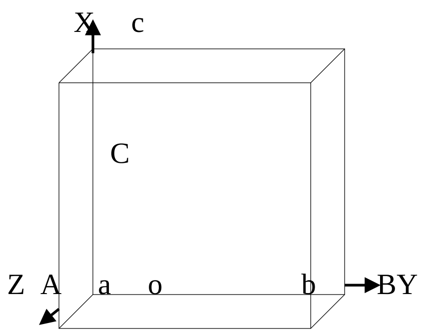
The smallest portion of a space lattice which can generate the complete crystal by repeating its own dimensions in various directions is called unit cell.

OA= a, OB = b, OC = c   are the dimensions of the unit cell.

The angles between a,b; b.c; c,a are denoted by γ, β, α .

γ, β, α are interfacial angles.

X, Y, Z are crystallographic axes.



5. Define primitive cell.

When the unit cell contains lattice points only at the corners, it is called a primitive cell. A minimum volume unit cell.

6. What are Bravais lattices?

Scientist Bravais introduced the space lattice idea to show that there are only 14 ways of arranging points in space so that the environment looks same from each point . These 14 space lattices are called bravais lattices.

7. **Define Effective number or no.of atoms per unit cell.**

It is defined as total no.of atoms present in or shared by an unit cell .

8. Define atomic radius.

It is defined as the half of the distance between any two nearest neighbour atoms.

9. Define packing factor.

$$Packing factor = \frac{Volume \quad occupied \quad by \quad the \quad total \quad no.of atoms/unit cell}{Total \quad volume \quad of \quad the \quad unit cell} = \frac{v}{V}$$

10. What are miller indices?

Scientist miller introduced a system (set of 3 numbers) to designate a plane in a crystal, is called miller indices of concerned plane.

These are three possible integers which have the same ratios as the reciprocal of the intercepts of the plane concerned along the 3 axes.

11. Define inter atomic distance and inter planar distance?

The distance between any two atoms is called inter-atomic distance.

The distance between any two planes is called inter-planar distance.

12. Role of imperfections in plastic deformation:

If a crystal is deformed by the applications of stresses, now it returns to its original state upon removal of the stresses, then the deformation is said to be elastic.

If that crystals retains its original state (deformed state), then it is said to be plastic.

In general, in most of the crystals the plastic deformations results from the slip of one part of the crystal relative to another.

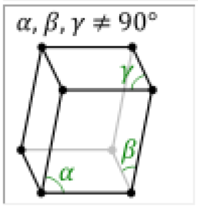
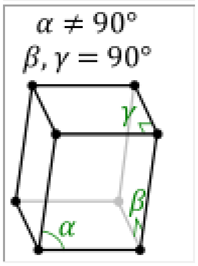
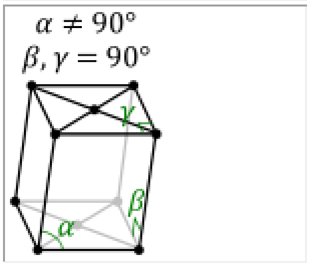
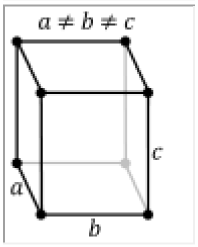
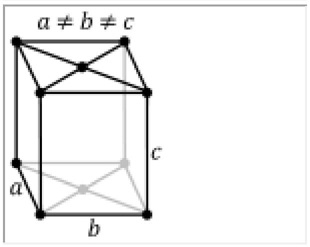
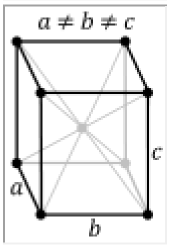
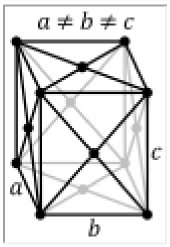
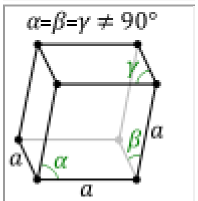
Slip is caused by the presence of dislocation, a connections between plastic deformation and dislocations must obviously exist.

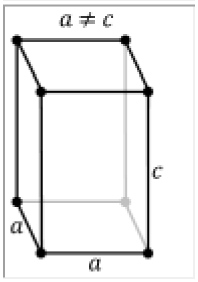
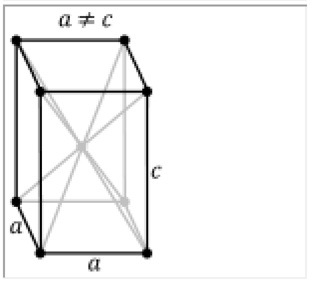
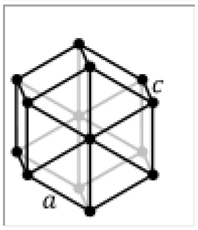
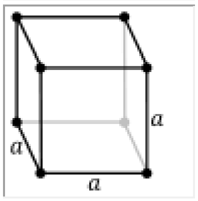
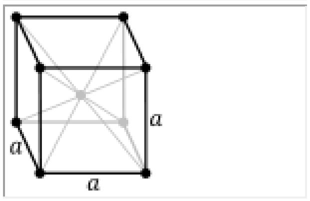
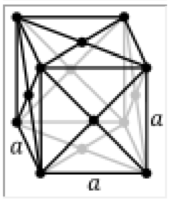
Part - B

1. **Describe the seven types of crystal system and fourteen types Bravais lattices?**

S.no	Crystal system	Unit cell parameters	Bravais lattice
1	Triclinic	$a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90^\circ$	Simple
2	Monoclinic	$a \neq b \neq c$ $\alpha \neq \beta = 90^\circ \neq \gamma$	Simple, Base – centred

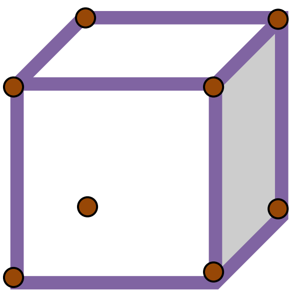
3	Orthorhombic	$a \neq b \neq c$ $\alpha = \beta = \gamma = 90^\circ$	Simple, Base-centred, Body-centred, Face centred
4	Tetragonal	$a = b \neq c$ $\alpha = \beta = \gamma = 90^\circ$	Simple ,Body-centred
5	Hexagonal	$a = b \neq c$ $\alpha = \beta = 90^\circ, \gamma = 120^\circ$	Simple
6	Trigonal	$a = b = c$ $\alpha = \beta = \gamma \neq 90^\circ$	Simple
7	Cubic	$a = b = c$ $\alpha = \beta = \gamma = 90^\circ$	Simple, Body centred, Face centred

The 7 lattice systems (From least to most symmetric)	**The 14 Bravais Lattices**				**Examples**
1. triclinic (none)					
2. monoclinic (1 diad)	simple	base-centered			
					
3. orthorhombic (3 perpendicular diads)	simple	base-centered	body-centered	face-centered	
					
4. rhombohedral (1 triad)					

5. tetragonal (1 tetrad)	simple	body-centered	
			
6. hexagonal (1 hexad)			
7. cubic (4 triads)	simple (SC)	body-centered (bcc)	face-centered (fcc)
			

2. **Calculate the no.of atoms per unit cell, coordination number, atomic radius, packing factor for simple cubic, Body centred cubic, Face centred cubic Structures.**

(i) SIMPLE CUBE



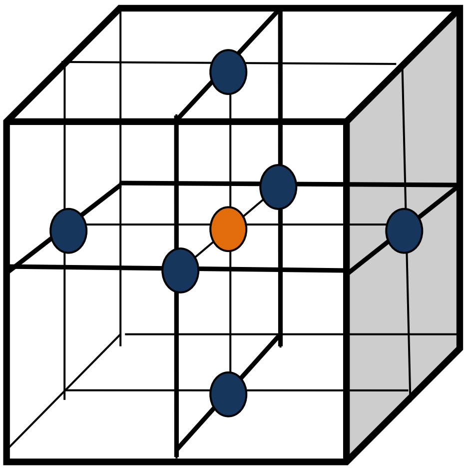
No.of atoms per unit cell: Cube has 8 corner atoms. Each corner atom is shared by 8 unit cells.

Therefore each atom contributes 1/8 of its part to a single unit cell.

Total no. of atoms/ unit cell = $\frac{1}{8} \times$ Total no of corner atoms = $\frac{1}{8} \times 8 = 1atom$

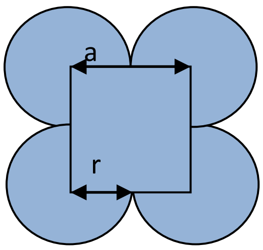
Co-ordination number:

There are 4 nearest atoms in horizontal plane and 2 nearest atoms in vertical plane. Therefore coordination number for cubic is 6.



Atomic radius: Here all atoms are touch each other. The distance between two atoms is equal to the edge of the cube.

Side of the unit cell. r- radius of the atom. Therefore r = a/2



Packing factor:

No.of atoms per unit cell= 1

Volume of 1 atom = $\frac{4}{3}\pi r^3$

If 'a' is a side of unit cell, Volume of the unit cell V=a^3

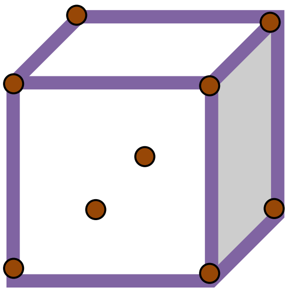
Packing factor = v/V

$$PF = \frac{\frac{4}{3}\pi r^3}{a^3} = \frac{\frac{4}{3}\pi r^3}{8r^3} = \frac{4\pi r^3}{24r^3} = \frac{\pi}{6} = 0.523$$

PF = 52%

52% of the volume is occupied by the atoms ,48% volume is empty. Ex: Polonium.

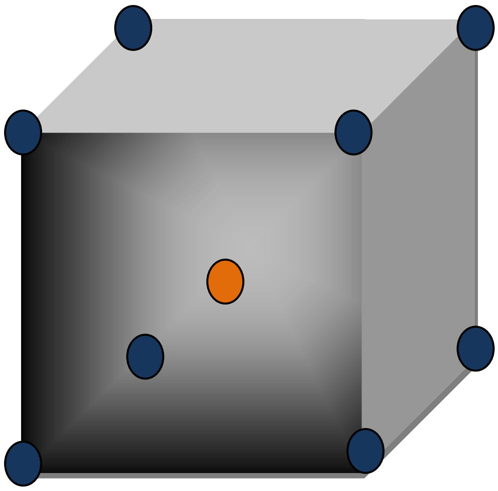
(ii)bBODY CENTRED CUBE:



In this case, the unit cell has eight corner atoms and one atom at the centre. Each corner atom is shared by eight unit cells. But the atom at the centre is exclusively for particular unit cell.

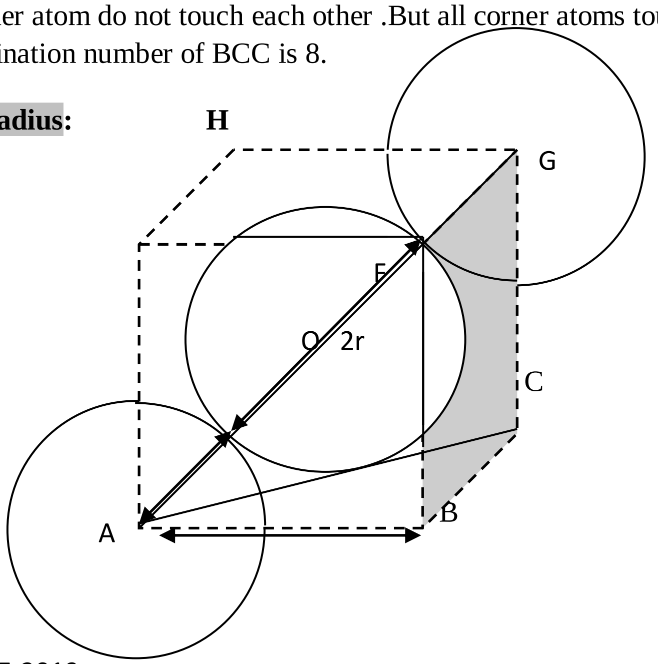
No.of atoms per unit cell: 8 corner atoms shared by 8 unit cells. Body centred atom is only for 1 unit cell. Therefore Total no.of atoms = $(\frac{1}{8}\times 8 = 1atom) + 1atom = 2atoms$

Co-ordination number:



Here corner atom do not touch each other .But all corner atoms touch the body centred atom. Hence the coordination number of BCC is 8.

Atomic radius:



a

consider the corner atoms at A,G and centred atom O. In triangle ABC,

$$AC^2 = AB^2 + BC^2$$
$$AC^2 = a^2 + b^2$$
$$AC^2 = AB^2 + BC^2$$
$$AC^2 = 2a^2$$

$$AG = r + 2r + r = 4r$$
$$squarring \quad on \quad both \quad sides$$
$$AG^2 = (4r)^2$$
$$In\Delta \quad ACG,$$
$$AG^2 = AC^2 + CG^2$$
$$\because (4r)^2 = 2a^2 + a^2 = 3a^2$$
$$r^2 = \frac{3a^2}{4^2};$$
$$r = \frac{\sqrt{3}a}{4}$$

Packing factor:

No.of atoms per unit cell = 2

Volume of 2 atoms, $v = 2 \times \frac{4}{3}\pi r^3$

Side of the unit cell $a = \frac{4r}{\sqrt{3}}$

Volume of the unit cell V= a^3

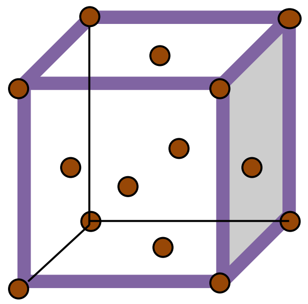
Packing factor P.F = v/V

$$P.F = \frac{2 \times \frac{4}{3}\pi r^3}{a^3}$$
$$substitute \quad a \quad value,$$
$$P.F = \frac{2 \times \frac{4}{3}\pi r^3}{[\frac{4r}{\sqrt{3}}]^3} = \frac{\frac{8}{3}\pi r^3}{\frac{64r^3}{3\sqrt{3}}} = \frac{8}{3}\pi r^3 \times \frac{3\sqrt{3}}{64r^3} = \frac{\sqrt{3}\pi}{8} = 68\%$$

68% of volume is occupied by atoms and 32% of volume is empty in BCC.

(ii)FACE CENTRED CUBE:

Here the unit cell has 8 corner atoms and in addition 1 atom at each face. Since each atom has 12 nearest neighbours, it is closely packed.



No.of atoms per unit cell: There are 8 corner atoms**.** Each corner atom is shared by 8 unit cells.

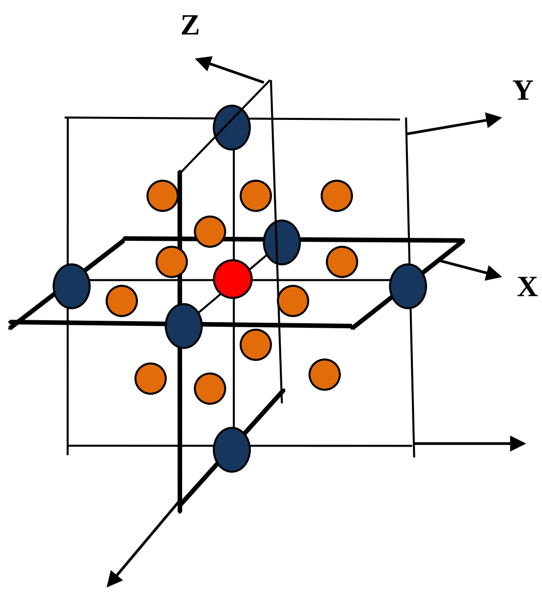
The contribution of corner atoms for a particular unit cell = $\frac{1}{8} \times 8 = 1 \quad atom$

There are 6 face centred atoms. Each atom is shared by 2 unit cells.

The contribution of face centred atoms to the unit cell = $\frac{1}{2} \times 6 = 3 \quad atoms$

$\therefore \; The \quad total \quad no.of \quad atoms \quad in \quad the \quad unitcell = 1 + 3 = 4$

Co-ordination number:

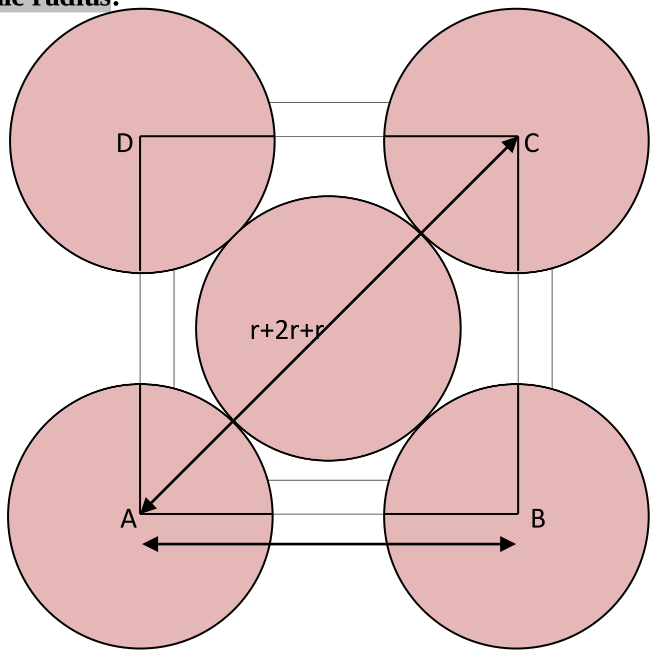


Consider a centre atom X. It has 4 nearest neighbour atoms along in x-plane, 4 nearest neighbour atoms along in y-plane and 4 more atoms in z plane.

Therefore total no.of nearest atoms to any corner atom = 12

Coordination number = 12

Atomic radius:



Atoms touch each other along the diagonal of any face.

In right angle ΔABC,

$$AC^2 = AB^2 + BC^2$$

$$(r + 2r + r)^2 = a^2 + a^2$$

$$16r^2 = 2a^2$$

$$\sqrt{r^2} = \frac{\sqrt{2a^2}}{\sqrt{16}}$$

$$r = \frac{a\sqrt{2}}{4}$$

Packing factor:

No.of atoms per unit cell = 4

Volume of 4 atoms , $v = 4 \times \frac{4}{3}\pi r^3$

Side of the unit cell $a = \frac{4r}{\sqrt{2}}$

Volume of the unit cell V= a^3

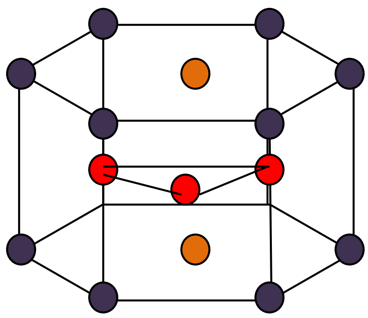
Packing factor P.F = v/V

$$P.F = \frac{4 \times \frac{4}{3}\pi r^3}{a^3}$$

substitute a value,

$$P.F = \frac{4 \times \frac{4}{3}\pi r^3}{[\frac{4r}{\sqrt{2}}]^3} = \frac{\frac{16}{3}\pi r^3}{\frac{64r^3}{2\sqrt{2}}} = \frac{16}{3}\pi r^3 \times \frac{2\sqrt{2}}{64r^3} = \frac{\pi\sqrt{2}}{6} = 74\%$$

3. Calculate the no. of atoms per unit cell, coordination number, atomic radius, packing factor for Hexagonal close-packed Structure.



There are 12 corner atoms in HCP structure. It has hexagonal prism shape. Each hexagon face possess an atom at its centre. 3 atoms symmetrically arranged in the body of the unit cell. Atoms are arranged in three layers. Top and bottom layer has 7 atoms for each. Middle layer has 3 atoms.

No.of atoms per unit cell:

Each corner atom is shared by 6 unit cells.

No.of atoms in the top hexagonal plane = $\frac{1}{6} \times 6 = 1$

No.of atoms in the bottom hexagonal plane = $\frac{1}{6} \times 6 = 1$

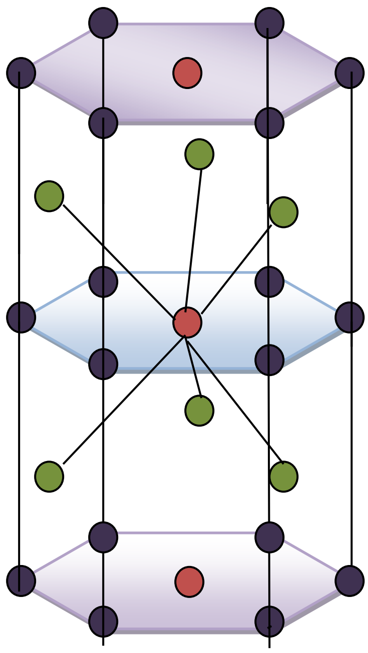
Central atom is shared by 2 unit cells.

No.of central atoms in both top and bottom hexagonal plane = $\frac{1}{2} \times 2 = 1$

There are 3 atoms at middle layer of unit cell. these are not shared by other unit cells.

Total no.of atoms in a HCP unit cell = 1+1+1+3=6

Co-ordination number:



Consider a central atom in middle layer , It has 6 nearest corner atoms . 3 nearest atoms above and 3 nearest atoms below to the concerned layer.

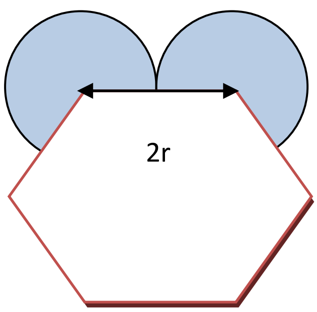
Therefore coordination number = 12.

Atomic radius:

Atoms touch each other along the edges of the hexagonal.

Therefore a = 2r .

Atomic radius r=a/2



Packing factor:

Volume of the atoms in a unit cell = No.of atoms x volume of one atom = 6 X $\frac{4}{3}\pi r^3$

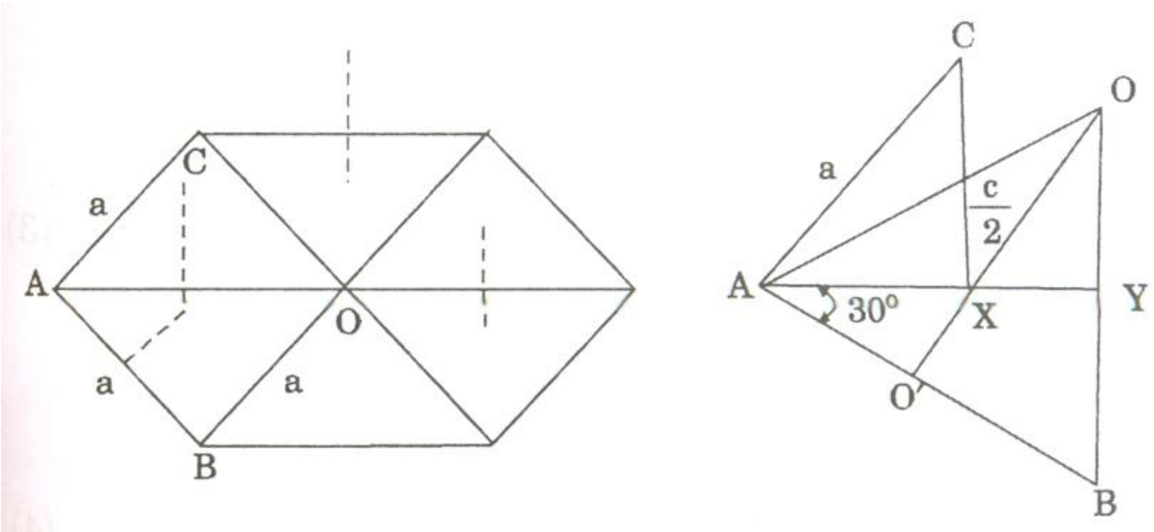
Substituting r = a/2

$$v = \frac{24}{3}\pi[\ \frac{a}{2}\ ]^3$$

$$v = \frac{24\pi a^3}{3\times a^3} = \frac{24\pi a^3}{3\times 8} = \pi a^3$$

Volume of the unit cell (V):

Calculation of c/a ratio:



c - Height of the unit cell of HCP.

a - Distance between 2 neighbouring atoms.

$$\Delta ABY, COS30^{\circ} = \frac{AY}{AB}$$

$$AY = ABCOS30^{\circ} = \frac{a\sqrt{3}}{2}$$

$$AX = \frac{2}{3}AY = \frac{2}{3}\frac{a\sqrt{3}}{2} = \frac{a}{\sqrt{3}}$$

$$In \Delta AXC, AC^2 = AX^2 + CX^2$$

$$Substitute \quad values \quad AC = a, AX = \frac{a}{\sqrt{3}}, CX = \frac{c}{2}$$

$$a^2 = [\ \frac{a}{\sqrt{3}}\ ]^2 + [\frac{c}{2}]^2$$

$$a^2 = \frac{a^2}{3} + \frac{c^2}{4}; \frac{c^2}{4} = a^2 - \frac{a^2}{3}$$

$$\frac{c^2}{4} = \frac{2a^2}{3} or \frac{c^2}{a^2} = \frac{8}{3}$$

$$\frac{c}{a} = 1.633$$

Area of the base =6 X Area of triangle AOB
Area of triangle AOB = 1/2 X (BO)(AY)

$$Area\ of\ triangle\ AOB = \frac{1}{2} \times a \times \frac{a\sqrt{3}}{2} = \frac{a^2\sqrt{3}}{4}$$

$$Area\ of\ base = 6 \times \frac{a^2\sqrt{3}}{4} = \frac{a^2 3\sqrt{3}}{2}$$

$$Volume \quad of \quad the \quad unit \quad cell(HCP) = base \quad area \times \quad height$$

$$V = \frac{a^2 3\sqrt{3}}{2} \times c$$

$$P.F = v/V$$

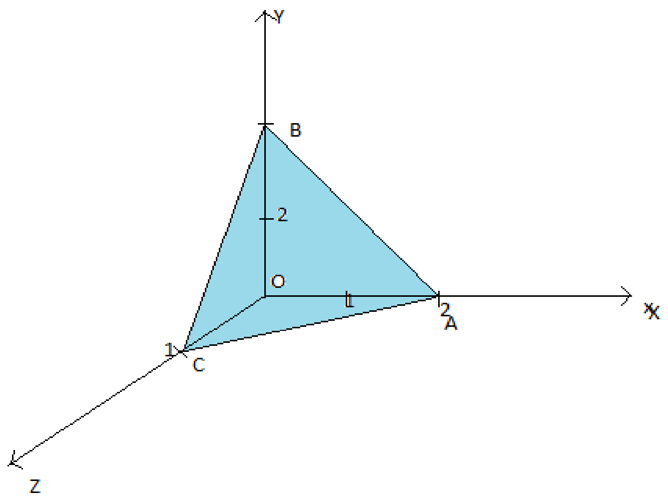
$$P.F = \frac{\pi a^3}{\frac{a^2 3\sqrt{3}}{2} \times c} = \frac{2\pi}{3\sqrt{3}} \ \frac{a}{c} = \frac{2\pi}{3\sqrt{3}}[\frac{3}{8}]^{\frac{1}{2}} \quad \because \frac{c}{a} = \sqrt{\frac{8}{3}}$$

$$= \frac{2\pi\sqrt{3}}{3\sqrt{3}\sqrt{8}} = \frac{2\pi}{3 \times 2\sqrt{2}}$$

$$= \frac{\pi}{3\sqrt{2}} = 0.74 = 74\%$$

74% of the volume is occupied by the atoms .Remaining 26% is empty.

4. What are miller indices? Explain how they are determined.



Scientist miller introduced a system (set of 3 numbers) to designate a plane in a crystal, is called miller indices of concerned plane.

These are three possible integers which have the same ratios as the reciprocal of the intercepts of the plane concerned along the 3 axes.

For ex. A plane ABC has intercepts of 2 axial units on x-axis, 2 axial units on Y -axis, 1 axial unit on Z-axis. The numerical parameters of this plane are 2,2and 1. Therefore its orientation is (2,2,1).

Miller suggested to describe the plane by the reciprocal of its numerical parameters. i.e [$\frac{1}{2} : \frac{1}{2} : 1$] or (112).

To get the whole numbers, all three reciprocals are multiplied by 2.

The general expression for miller indices of a plane = (h k L).

Steps to find miller indices:

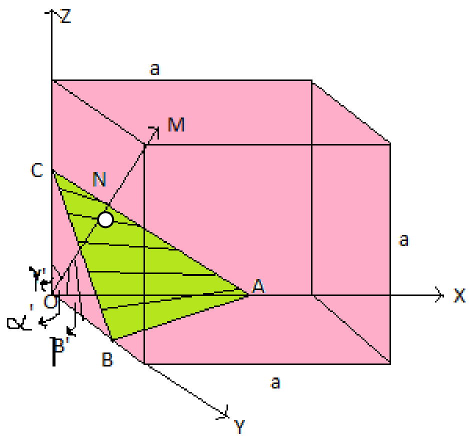
Find the intercepts of the plane along the coordinates axes X, Y, Z.

Take the reciprocal of these intercepts.

The reciprocal s are multiplied by LCM number.

Write these integers within the parenthesis.

5. Derive an expression to find 'd' spacing in cube lattice.



Consider a cubic crystal . a is side of the cube edge. ABC is a reference plane.

ON is perpendicular to the plane ABC.

OA,OB,OC are intercepts of plane ABC. α', β', γ' are the angles between reference axes OX,OY,OZ.

Therefore the miller indices of intercepts,

$$OA : OB : OC = \frac{1}{h} : \frac{1}{k} : \frac{1}{l} = \frac{a}{h} : \frac{a}{k} : \frac{a}{l}$$

$$OA = \frac{a}{h}; OB = \frac{a}{k}; OC = \frac{a}{l}$$

$$In \Delta OAN, OBN, OCN,$$

$$\cos\alpha' = \frac{ON}{OA} = \frac{d}{a/h} = \frac{dh}{a}$$

$$\cos\beta' = \frac{ON}{OB} = \frac{d}{a/k} = \frac{dk}{a}$$

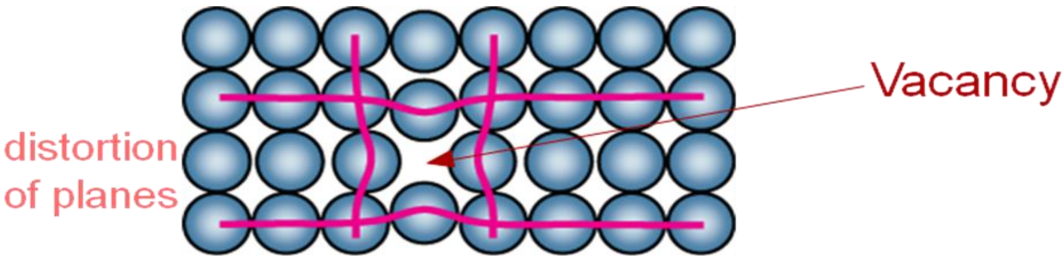
$$\cos\gamma' = \frac{ON}{OC} = \frac{d}{a/l} = \frac{dl}{a}$$

$$Thelawof - direction - \cos ines,$$
$$\cos^2 \alpha' + \cos^2 \beta' + \cos^2 \gamma' = 1$$
$$\left[\frac{dh}{a}\right]^2 + \left[\frac{dk}{a}\right]^2 + \left[\frac{dl}{a}\right]^2 = 1$$
$$\frac{d^2h^2}{a^2} + \frac{d^2k^2}{a^2} + \frac{d^2l^2}{a^2} = 1$$
$$d^2 = \frac{a^2}{(h^2 + k^2 + l^2)}$$
$$d = \frac{a}{\sqrt{(h^2 + k^2 + l^2)}}$$

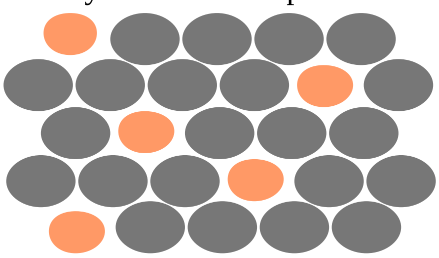
7. Describe the various types of crystal defects with suitable diagrams.

Point defects:

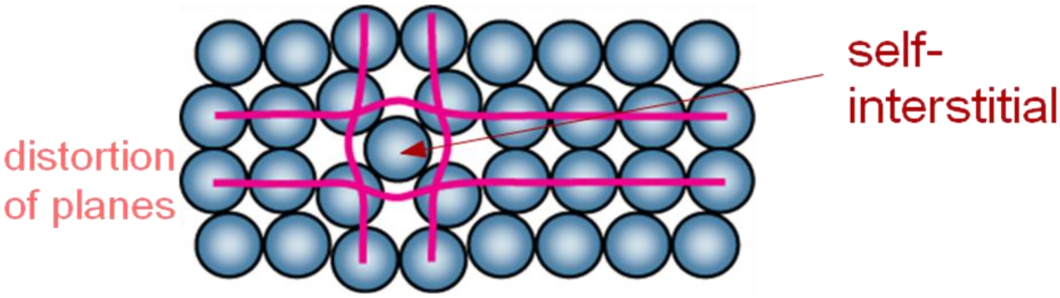
1. **Vacancies:** When ever one are more atoms are missing from a normally occupied position, the defect caused is known as Vacancy .



2. **Substitutional impurity:** Whenever a foreign atom occupies a position, which was initially meant for the parent atom, the defect is known as substitutional defect.



3. **Interstitial impurity:** Whenever an extra atom occupies interstitial sites namely voids in the crystal , the defect resulted is known as interstitial defect.



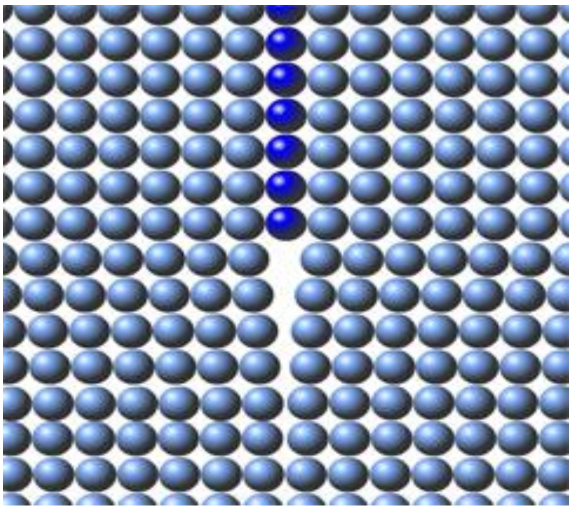
4. **Frenkel defect:** Whenever a missing atom occupies an interstitial position, the defect caused is known as frenkel defect. This defect is more common in ionic crystals.

5. **Schottky defect:** Whenever a pair of positive and negative ions is missing from a crystal, the defect caused is known as schottky defect.

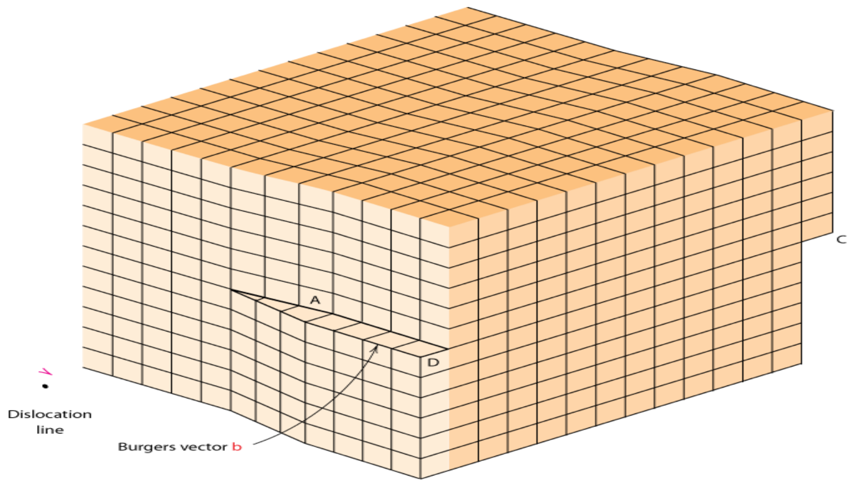
LINE DEFECTS:

1. **Edge dislocation:** This misalignment of atoms in a one dimensional array or in a linear way is called as a linear defect or dislocation.

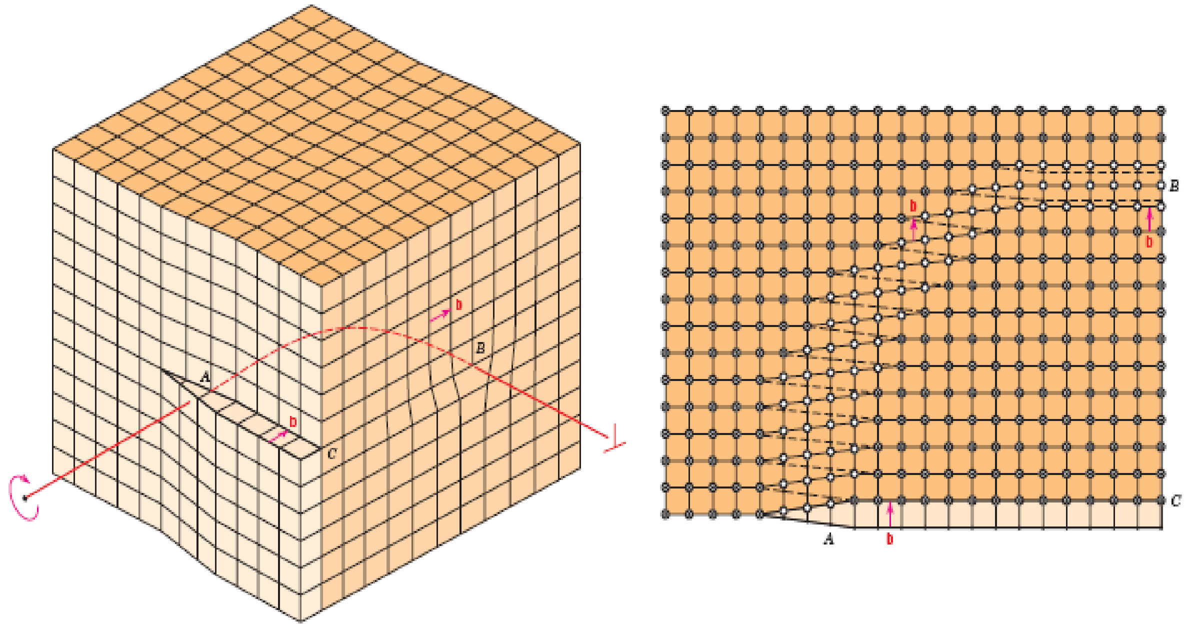
   The edge of an extra portion of plane of atoms or half plane terminates within the crystal. This is termed as edge dislocation.



2. **Screw dislocation:** This defect or dislocation is due to shear stress, produced due to the distortion in the upper front region of the crystal that is shifted one atomic distance to the right relative to the bottom portions.



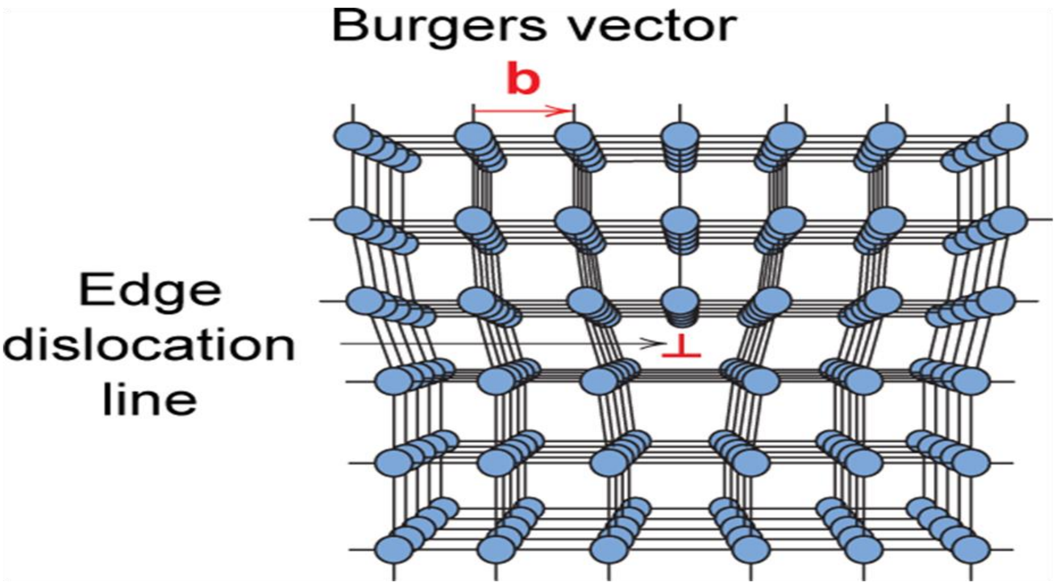
(a)



Burgers vector:

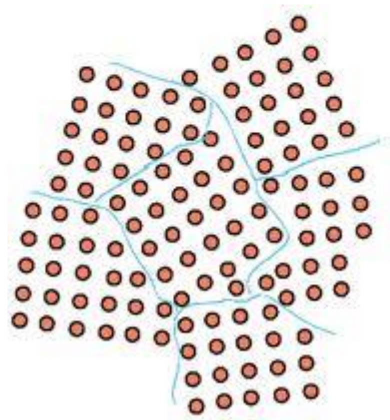
It denotes the magnitude and direction of lattice distortion associated with a dislocation.

The magnitude and direction of lattice distortion associated with a dislocation is expressed in terms of a Burgers vector, denoted by ‘b’.

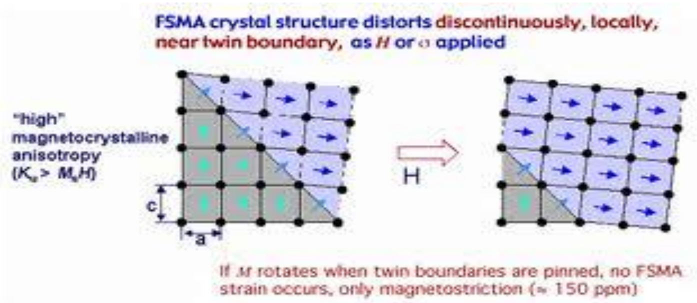


SURFACE DEFECTS:

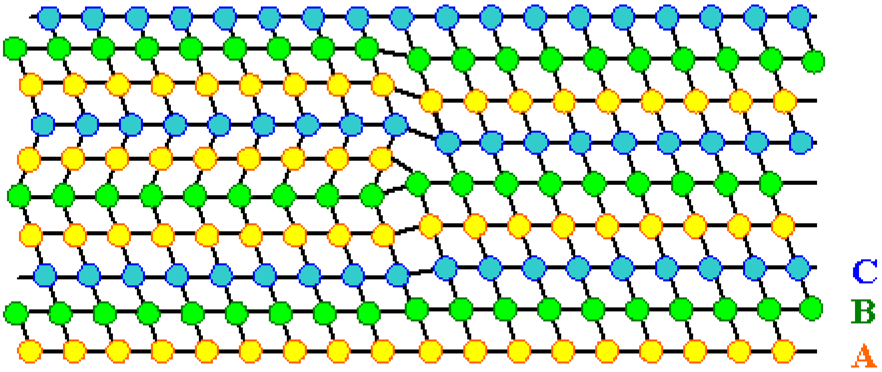
1. **Grain boundary:** Whenever the grains of different orientations separate the general pattern of atoms and exhibit boundary as shown in fig, the defect caused is known as grain boundary.



2. **Twin boundary:** When the boundaries in which the atomic arrangement on one side of the boundary is a somewhat mirror image of the arrangement of atoms on the other side as shown in fig, the defect caused is known as twin boundary.



3. **Stacking faults:** Whenever the stacking of atoms is not in a proper sequence throughout the crystal, the fault is known as stacking fault.



questions	opt1	opt2	opt3
The modulus of elasticity is dimensionally equivalent to	Strain	Stress	Surface tension
If by applying a force, the shape of a body is changed, then the corresponding stress is known as	Tensile stress	Bulk stress	Shearing stress
According to Hooke's law of elasticity, within elastic limits, if the stress is increased, the ratio of stress to strain	Increases	Decreases	Becomes zero
Which one of the following does not affect the elasticity of a substance?	Hammering	Adding impurity in the substance	Changing the dimensions
The bulk modulus of a fluid is inversely proportional to the	Change in pressure	Volume of the fluid	Density of the fluid
Shearing strain is given by	Deforming force	Shape of shear	Angle of shear
The ratio of the change in dimension at right angles to the applied force to the initial dimension is known as	Young's modulus	Poisson's ratio	Lateral strain
Which of the following is dimensionless quantity?	Stress	Young's modulus	Pressure
The energy per unit volume of a stretched wire is	1/2 *stress *strain	strain*stress	1/2 *load *extension
Out of the following materials, whose elasticity is independent of temperature?	Copper	Invar steel	gold
Theoretical value of Poisson's ratio lies between	- 1 to 0.5	-1 to -2	0.5 to 1
Strain has	No units but only dimensions	Only units but no dimensions	No units, no dimensions but a constant value
When impurities are added to an elastic substance, its elasticity	Increases	Decreases	Becomes zero
Longitudinal strain is possible in the case of	Gases	Liquid	only solids
When the intermolecular distance increases due to tensile force, then	There is no force between the molecules	There is a repulsive force between the molecules	There is an attractive force between the molecules
If a material is heated and annealed, then its elasticity is	Increased	Decreased	Not change
Hooke's law essentially defines	stress	strain	yield point
The Young's modulus for a plastic body is	one	zero	infinity
Which of the following have highest	steel	copper	rubber

Energy in a stretched wire is	Half of load x strain	Half of stress / strain	Stress x strain
The property due to which then sheets can be prepared from a material is called	Elasticity	Brittleness	Malleability
The substance which shows practically no elastic effect is	Quartz	Copper	silk
In uniform bending experiment ,which property can be calculated	Rigdity modulus	youngs modulus	bulk modulus
In torsional pendulam experiment ,which property can be calculated	Rigdity modulus	youngs modulus	bulk modulus
The property by virtue of which a deformed body tends to regain its original shape after the removal of deforming forces is called --------	Elasticity	Plasticity	Rigidity
Restoring force per unit area is given by	Stress	Strain	Modulus
Unit of stress is -----	Nm^-2	Nm^2	Nm^3
Unit of strain is -------	Metre	Metre^3	No unit
Based on Hookes law stress is directly proportional to-----	Modulus	Strain	Stress
Young’s modulus = Longitudinal stress/-----------	Longitudinal strain	Lateral strain	Shearing strain
The ratio of tangential stress to shearing strain is ------------	Young’s modulus	Rigidity modulus	Bulk modulus
Volume stress/volume strain is known as --------	Poisson’s ratio	Bulk modulus	Rigidity modulus
Relationship between three modulli of elasticity is -------	3K+G/ 9Gk	9GK/ 3k+G	9Gk/9G+K
A rod of uniform cross section with greatest length is known as -----	Bar	Beam	Cantilever
If a beam fixed horizontally at one end and loaded at the other end is known as-----	Bar	Cantilever	Support
Poisson's ratio = ------	lateral strain/ longitudinal strain	lateral stress /lateral strain	longitudinal stress/strain
What is the ratio of stress to tensile strain called?	Poisson’s ratio	Pascal law	Hooke's law
What is the SI unit of pressure?	Nm	Nm^-1	Nm^-2
What is the density of air?	1.3	13.6	9.23

opt4	opt5	opt6	answer
Poisson’s ratio			Stress
Compressive stress			Shearing stress
Remains constant			Remains constant
Change of temperature			Changing the dimensions
Change in its volume			Change in its volume
Change in volume of body			Angle of shear
Shearing strain			Lateral strain
Strain			Strain
load* Extension			1/2 *stress *strain
Silver			Invar steel
1 to 2			- 1 to 0.5
No units, no dimensions but a variable value			No units, no dimensions but a variable value
May increase or decrease			May increase or decrease
Only gases & liquids			only solids
There is zero resultant force between the molecules			There is an attractive force between the molecules
Becomes zero			Decreased
elastic limit			elastic limit
less than one			zero
aluminium			steel

Load / strain	Half of load x strain
Ductility	Malleability
Rubber	Quartz
none	youngs modulus
none	Rigdity modulus
Moldity	Elasticity

Shearing strain	Stress
Nm^-1	Nm^-2
Stress	No unit
Elasticity	Strain
Bulk strain	Longitudinal strain
Poisson’s ratio	Rigidity modulus
Young’s modulus	Rigidity modulus
3K-2G/6K+2G	9GK/ 3k+G
support	Beam
Beam	Cantilever
stress/strain	lateral strain/ longitudinal strain
Youngs modulus	Youngs modulus
Nm^-3	Nm^-2
123.32	1.3

S.NO	QUESTIONS
1	The frequency of ultrasonic waves is -----------
2	The ultrasonic waves are ------------------- frequency waves
3	The ultrasonic waves are ------------ to human ear
4	The ultrasonic has many advantages based on the principle that sound waves are at the boundary of two surfaces.
5	which one of the method used for production of ultrasonic waves?
6	-------------------- is the principle used for the production of ultrasonic waves.
7	Which one of the following is the ferromagnetic material ?
8	When a coil is wounded over a vibrating rod then -----------------will be induced in the coil.
9	Magnetostriction generator can produce frequency upto
10	------------- is the example of piezo-electric crystal.
11	Quartz crystal has ------------ shape with pyramids attached at both ends.
12	Electrical axis in a crystal is otherwise known as
13	Optical axis in crystal is known as
14	Mechanical axis in a crystal is known as
15	When the crystal is cut perpendicular to y-axis is
16	Y-cut crystal produces ---------------- ultrasonic waves.
17	------------ is the priciple behind the production of ultrasonic waves using piezo-electric oscillator circuit.
18	The piezo-electric generator can produce frequency
19	The production of ultrasonic waves is ------------ temperature.
20	When ultrasonic waves passes through liquid it produces ------------- wave pattern
21	When ultrasonic waves passed through a liquid, its density varies due to variation in pressure and hence the liquid act as
22	The acoustic grating method is used to measure ----------- of the ultrasonic waves.
23	.Based on------------ principle the ultrasonic waves are used in SONAR.
24	---------- is used to examine the material to detect imperfections and properties without damaging the material.
25	In NDT the time consumption is
26	----------------- is the principle used in ultrasonic flaw detector.
27	A-scan display gives ------------- information about the specimen.
28	A-scan method is used to detect-------and ---------- of flaws.
29	Brightness mode (or) B-scan display gives a ---------- image.
30	B-scan provides exact information about ---------- structures of the specimen.
31	TM scan display gives ------------- images of the specimen
32	When sound interacts with materials and boundaries, it displays all properties of
33	Both bats and dolphins have ability to “see” using
34	Soft materials absorb large amount ofheat energy
35	Echo of sound is more prominent if surface is
36	Velocity (speed) of sound is ________
37	What is the Speed of sound in air?
38	Sound can be produced by ______
39	Loudness and pitch are determined by ____ and ____ respectively.

40	Bending of light as it passes from one medium to another is called

OPT 1	OPT 2	OPT 3	OPT 4
> 20,000	< 20,000	20-20,000	10,000 only
low	.medium	high	normal
inaudiable	audible	pleasant	noise
refracted	absorbed	diffracted	reflected
kundts tube method	thermal method	NDT method	galton whistle method
negative local pressu	magnetostriction effect	piezo electric effect	both a&c
cobolt	cupper	zinc	aluminium
voltage	resistance	e.m.f	current
10 MHz	2Mhz	3 M Hz	5MHz
nacl	kcl	quartz	ferromagnetic rod
.hexagonal	triangle	circle	cube
y-axis	x-axis	z- axis	x and y
z-axis	x-axiz	y-axis	x and y
optic axis	z-axis	x- axis	x or y
y cut crystal	x cut crystal	z cut crystal	none
longitudinal	vertical	horizontal	traverse
piezo-electric effect	magnetostriction effect	stark effect	inverse piezo electric effe
below 500 Mhz	upto 500Mhz	500 mHz	50 Hz
dependent	normal	constant	independent
stationary	longitudinal	.transverse	.plane
diffraction grating	acoustical grating	both a&b	none
velocity	density	temperature	pressure
echo sounding	negative local pressure	coagulation	superposition
NDT	DT	SONAR	LASER
zero	high	low	moderate
.change in volume	change in medium	change in temperature	change in pressure
1D	3D	2D	none
position & size	pressure & volume	temperature &velocity	density &viscosity
3D	4D	1D	2D
external	internal	tranverse	longitudinal
3D	2D	1D	none
heat	waves	light	electricity
electric waves	heatwaves	sound waves	lightwaves
heat energy	light energy	EM waves	sound energy
soft	rigid	porous	smooth
1/frequency	wavelength/frequency	frequency x wavelength	frequency
343m/s	340m/s^2	330m/s	300m/s
vibration	angular motion	transverse motion	lontgitudinal motion
timbre and quality	Amplitude and Frequency	wavelength and frequenc	frequncy only

reflection	refraction	rarifaction	difraction

ANS	
> 20,000	1
high	3
inaudiable	1
reflected	4
galton whistle meth	4
both a&c	4
cobolt	1
e.m.f	3
3 M Hz	3
quartz	4
.hexagonal	1
x-axis	2
z-axis	1
y-axis	4
y cut crystal	1
traverse	4
inverse piezo electri	4
upto 500Mhz	2
independent	4
stationary	1
diffraction grating	3
velocity	1
echo sounding	1
NDT	1
low	3
change in medium	2
1D	1
position & size	1
2D	4
internal	2
3D	1
waves	
sound waves	
sound energy	
rigid	
frequency x wavelength	
343m/s	
vibration	
Amplitude and Frequency	

refraction		

questions	opt1
If there is no transfer of energy between two objects then their temperature is	same
Heat is transferred in solids by _______.	radiation
Bad conductors are also called _______.	insulators
Heat is measured in	joule
In a refrigeration system, the expansion device is connected between the	Compressor and condenser
Quantity of thermal energy absorbed by a body for 1 kelvin increase in its temperature is known as	heat capacity
Gaps are left in railway tracks to compensate thermal expansion during	rainy season
An increase in breadth, length and thickness of a substance is due to	fusion
The coefficient of thermal conductivity of a rubber can be determined by the principle of_______________ flow of heat.	Rectilinear
Lee's method for bad conductors a steady current passed through _______________.	heater coil
Thermal diffusivity is defined as ___________.	ratio of thermal conductivity to thermal capacity per unit volume
Thermal capacity of a good conductor is determined by	Lee's method
Which of the following has highest heat capacity?	metal
Which law gives the relation between the work done and the heat produced?	Dulong and petit's law
Molecules of a solid vibrate with larger amplitude at	zero temperature
Heat is transferred in gases by	radiation
Which of the following is not a commom microwave application?	radar
Microwave oven operates at a frequency of ___________.	1.37 GHz
During a refrigeration cycle,heat is rejected by the refrigerant in a.......	Condenser
One tonne of refrigeration is equal to	21/kJ/min
Air refrigeration cycle is used in.......	Commercial refrigerators
Which of the following refrigerant is highly toxic and flammable.......	Ammonia
Which of the following refrigerant has the lowest boiling point?.......	Ammonia
What is the principle of domestic refrigerator?	zeroth law
The ceramic oven is constructed using ________.	Clay
For the same heat transfer Q and same overall heat transfer coefficient Uo, surface area required for cross flow operation is always	less than LMTD for parallel flow

In parallel flow heat exchangers,	the exit temperature of hot fluid is always equal to the exit temperature of cold fluid
For the same heat transfer Q and same overall heat transfer coefficient Uo, surface area required for parallel flow operation is always	less than LMTD for counter flow
For the same inlet and exit temperatures of two fluids, the LMTD for counterflow is always	smaller than LMTD for parallel flow
Which of the following temperature difference is safer than other to consider in designing of heat exchangers?	Arithmetic Mean Temperature Difference
When is the arithmetic mean temperature difference of heat exchanger used instead of LMTD?	when the temperature profiles of two fluids of heat exchanger are sloping downward with curve
How can the arithmetic mean temperature difference and LMTD of a same heat exchanger be compared?	the arithmetic mean temperature difference is less than LMTD of a same heat exchanger
The response of a material due to the function of heat is known as __________	Mechanical property
Tendency of matter to change in shape, area, and volume in response to a change in a particular temperature is called	non linear expansion
Internal energy comprises of two types of energies, those are	mechanical and electrical energy
A pure substance would freeze or solidify at its	boiling point

Which of following does not belong to list of factors that affect rate of transfer of energy by radiation?	Color and texture of the surface
Rate of transfer of energy by radiation can be increased by	increasing the surface temperature
Vacuum in a vacuum flask prevents heat transfer through process of	Conduction only
With respect to heat transfer through conduction, which of following inequalities place solids', 'liquids' and 'gases' in right order?	Solids < liquids < gases
A perfect black body is one which ________________ all the radiations.	Absorbs
The classical theory was not able to explain the ___________.	diffraction
The discrete energy values in the form of quantum of definite frequency are calle	phonons
Which of the following are not affected by the magnetic field?	electrons
The relation between energy and the momentum of the photon is ___________.	P=EC
The wave associated with a material particle are called as __________.	standing wave
De-Broglie wavelength in terms of energy is _________.	h/2mE
De-Broglie wavelength in terms of voltage is __________.	h/2mV
According to ___________ theory the hydrogen spectrum is a continuous spectr	classical
According to ___________ theory the hydrogen spectrum is a discrete spectrum.	classical
The de-Broglie wavelength of an electron of energy 100 eV is ________.	12.27 Angstro
In one dimensional potential box,the potential energy of the electron inside the b	maximum
According to quantum mechanics, the energy levels of an electron are_______	continuous
Source used in the SEM is ___________.	electrical enre
Knowledge of the wave function of a particle enables the probabilities of the par	particle's m
The speed of propagation of an electromagnetic wave in vacuum is:	3 x (10)^ 6 m
The expression of the momentum of a photon is :	p = h * lamda
If the uncertainty of a proton accelerated in a laboratory is 400 m/s, that of its po	7.88 nm
Planck's constant has the same units as______________.	angular mome
Which of the following is known as the Schrodinger equation ?	E = h* nu
The principle that all microscopic physical entities have both wave and particle p	singularity
In the probabilistic interpretation of wave function Ψ, the quantity $\lvert\Psi\rvert$ ^2 is:	a probability c
Quantum Mechanics is also called as _________.	Classical Mec
Classical Mechanics failed to explain _________.	Thermodynan
Quantum Theory was indtroduced by _________.	Max Planck
As temperature increase, the peak wavelength emitted by the black body_______	Increases
As temperature increase, the total energy emitted by black body _____________	No Change
According to de-braglie wave equation, when mass of the particle decreases wav	Decreases
Speed of Light ___________.	3× (10)^8 m/s
A particle in one dimensional box at the walls of the box potential Energy will b	Increases
Photons propagate with ______________ speed of light.	smaller
According to de-broglie wave equation, when mass of the particle increases wav	Decreases
Black body emits radiation in ____________.	visible region
According to plancks quantum theory,electrons in the black body radiator are ass	electric oscill

The black body radiator emits energy in _____________.	discrete
The term kB represents _____________.	Bohr radius
Expression for momentum is _____________.	p = 2 m v
(Delta)^2 represents _____________.	Hermition ope
Relation between angular and linear frequencies is _____________.	omega = nu/2
Which one of the following is true?	nu= p/lamda
For a free particle, potential energy is _____________.	0
According to de-broglie wave equation, when velocity of the particle increases w	Doubles
A particle in one dimensional box at the walls of the box wave function will be _	Increases
Energy of photon is directly related to the ______________.	wavelength
Calculate the minimum uncertainty in velocity of an electron trapped in 30.3nm	1.20 x 10^4 m
Frequency below which no electrons are emitted from metal surface is ________	minimum freq
Loss of energy of an electron results in ____________.	absorption of
Electrons show diffraction effects because their de Broglie wavelength is similar	spacing betwe
Wavelength of ultraviolet region of electromagnetic spectrum is ______________	121 nm
A perfect black body is a perfect absorber and radiator of _____________ radiatic	monochromat

opt2	opt3	opt4	opt5	opt6	answer
different	zero	infinite			same
convection	conduction	fusion			conduction
convectors	radiators	termaids			insulators
kelvin	celsius	joule second			joule
Condenser and receiver	Receiver and evaporator	Evaporator and compressor			Receiver and evaporator
pressure capacity	Kinetic energy	potential energy			heat capacity
winter	hot season	wind			hot season
thermal expansion	stress	boiling			thermal expansion
Cylindrical	Radial	Axial			Cylindrical
thermo couples	thin disk	copper plates			heater coil
directly proportional to the thermal conductivity	inversely proportional to thermal conductivity	directly proportional to the square of the thermal conductivity			ratio of thermal conductivity to thermal capacity per unit volume
Forbe's method	Searle's apparatus	Charlton’s method			Lee's method
soil	water	air			water
Newton’s law	Kirchoff’s law	Joule’s law			Joule’s law
lower temperature	higher temperature	pressure			higher temperature
convection	conduction	fusion			convection
mobile radio	telephone	satellite communication			mobile radio
1.45 GHz	2.45 GHz	3.94 GHz			2.45 GHz
Compressure	Evaporator	Expansion valve			Condenser
210/kJ/min	420/kJ/min	620/kJ/min			210/kJ/min
Domestic refrigerators	Air-conditioning	Gas liquefaction			Gas liquefaction
Carbon dioxide	Sulphur dioxide	Freon-12			Ammonia
Carbon dioxide	Sulphur dioxide	Freon-12			Carbon dioxide
First law	Second law	third law			Second law
Glass	Plastics	Rubber			Clay
more than LMTD for parallel flow	same as LMTD for parallel flow	unpredictable			less than LMTD for parallel flow

the exit temperature of hot fluid is always less than the exit temperature of cold fluid	the exit temperature of hot fluid is always more than the exit temperature of cold fluid	we cannot predict comparison between exit temperatures of hot fluid and cold fluid	the exit temperature of hot fluid is always more than the exit temperature of cold fluid
more than LMTD for counter flow	same as LMTD for counter flow	unpredictable	more than LMTD for counter flow
greater than LMTD for parallel flow	same as LMTD for parallel flow	unpredictable	greater than LMTD for parallel flow
Logarithmic Mean Temperature Difference (LMTD)	Both have nothing to do with safety	Other	Logarithmic Mean Temperature Difference (LMTD)
when the temperature profiles of two fluids of heat exchanger are sloping upward with curve	when the temperature profiles of two fluids of heat exchanger are straight	when the temperature profiles of two fluids of heat exchanger are quadratic	when the temperature profiles of two fluids of heat exchanger are straight
the arithmetic mean temperature difference is more than LMTD of a same heat exchanger	the arithmetic mean temperature difference and LMTD of a same heat exchanger are equal	the arithmetic mean temperature difference is double than LMTD of a same heat exchanger	the arithmetic mean temperature difference is more than LMTD of a same heat exchanger
Electrical property	Chemical property	Thermal property	Thermal property
electrical expansion	thermal expansion	mechanical expansion	thermal expansion
magnetic and electrical energy	kinetic and potential energy	kinetic and magnetic energy	kinetic and potential energy
condensation point	melting point	sublimation point	melting point

Temperature of the surface	Movement of air above the surface	Surface area	Movement of air above the surface
decreasing the surface area	using shiny white surfaces instead of dull and black surfaces	decreasing the atmospheric pressure	increasing the surface temperature
Convection only	Conduction and Convection	Radiation only	Conduction and Convection
Solids < gases < liquids	Solids > gases > liquids	Solids > liquids > gases	Solids > liquids > gases
emits	absorbs and emit	reflects	absorbs and emits
interference	emission of black	scattering	emission of black body ra
photons	neutrons	scattering	photons
protons	photons	positive ions	photons
E=P/C	C=EP	E=PC	E=PC
progressive wav	transverse wave	matter wave	matter wave
h/sqrt(2mE)	h/2mEe	h/2m	h/sqrt(2mE)
h/2mE	h/2m	h/sqrt(2meV)	h/sqrt(2meV)
quantum	Electro magnetic	wave	classical
quantum	electro magnetic	electro magnetic	quantum
122.7 Angstrom	1.227 Angstrom	0.1227 Angstrom	1.227 Angstrom
minimum	zero	infinity	zero
discrete	scattering	diffraction	discrete
chemical source	electron gun	neutron gun	electron gun
particle’s energy	particle’s mass	The sum of the forces on the particle	particle’s mass
3 x (10)^8 m/s	3 x (10)^8 km/s	3 x (10)^ (-8) km/s	3 x (10)^8 km/s
p = h / lamda	p = c/lamda	p = c*lamda	p = c/lamda
9.70 nm	112 nm	115nm	7.88 nm
the Hamiltonian	frequency	de Broglie wavelength	angular momentum
E = m* (c)^2	H* Psi = E* Psi	lamda = h/p	H* Psi = E* Psi
duality	triality	infinality	duality
a probability am	1	0	a probability density
Wave mechanics	Statistical mecha	Newtonian mechanics	Wave mechanics
Electromagnetic	Atomic Spectra	Velocity of Particle	Atomic Spectra
De-Broglie	Newton	Einstein	Max Planck
No Change	Decreases	Saturates	Decreases
Decreases	Saturates	Increases	Increases
Increases	Doubles	Zero	Increases
(2.5)×(10)^8 m/s	(3.5)×(10)^8 m/s	2×(10)^8 m/s	3× (10)^8 m/s
Decreases	Zero	infinity	infinity
greater	equal	same	same
Increases	Doubles	Zero	Decreases
single wavelengt	Discrete wavelen	All wavelengths	All wavelengths
harmonic oscilla	simple pendulum	non-linear oscillators	harmonic oscillators

continuos	pulse	wave	discrete
Plancks constant	Boltzmann consta	Stefans constant	Boltzmann constant
p = m v	p = h *nu	p = h*(nu)/c	p = m v
Laplacian operat	Energy operator	Hamiltonion operator	Laplacian operator
omega = 2*pi/nu	omega = 2*pi*nu	nu= 2*pi*omega	omega = 2*pi*nu
nu= c/lamda	lamda = nu*c	lamda = 1/nu	nu= c/lamda
1	2	3	0
Increases	Decreases	Zero	Decreases
Decreases	Zero	infinity	Zero
wave number	frequency	amplitude	frequency
2.87 x 10^4 m/s	1.20 x 10^ 6 m/s	1.20 x 10^5 m/s	1.20 x 10^4 m/s
angular frequenc	maximum freque	threshold frequency	threshold frequency
emission of phot	destruction of ph	formation of photon	emission of photon
no. of atomic lay	nature of atomic l	positioning of atomic layers	spacing between atomic la
120 nm	119 nm	130 nm	121 nm
all wavelengths (	coherent	polychromatic	all wavelengths of

diation

ayers

questions	opt1	opt2
The laser beam from laser source has frequency upto ______________ leads to many scientific applications.	109HZ	109KHZ
The angular spread (or) divergence of a laser beam is _____________.	1m/m	1 µm/m
The laser source emitting radiation are________________.	polychromatic in nature	not in phase
In a given light beam containing wave trains of same frequency are in phase means that light beam is__________________.	ordinary light beam	extradinary light beam
The spontaneously emitted photons are__________________.	high intense & incoherent	less intense & coherent
During population inversion, the number of atoms in excited state can be made more than ground state only under____________________ condition.	high pressure	negative temperature
The method of pumping used in Carbon dioxide laser is__________________.	optical pumping	direct electron excitation
Active centre of Carbon dioxide laser is__________________.	nitrogen & helium	water vapour
Active medium of homo juction semiconductor laser is__________________.	silicon	P-N junction diode
Active centre of hemojuction semi conductor laser is__________________.	neon	P-N junction diode
The wavelength of laser beam emitted by homojuction semiconductor laser source is_____________________.	8400 µm - 8600 µm	8400A-8600A
Which of the following act as a optical resonator of homojuction semiconductor laser?	metallic mirror	silver coated mirrors
Gallium Arsenide acts as optical resonator in homojuction semiconductor laser due to its____________________.	high refractive index	low refractive index
The method of pumping used in heterojunction semiconductor laser is_____________________.	optical pumping	chemical process
The wavelength of laser beam emitted by heterojunction semiconductor laser is________________.	6382 A	5892 A
The wavelength of laser beam emitted by the Gallium Arsenide semiconductor laser is_____________________ ,its band gap is 1.44 eV	5892 A	1.06 µm

The wavelength of laser beam emitted by the GaAlAs laser is _______________ ,its band gap is 1.55 eV.	5892 A	1.08 µm
The method of pumping used in homojunction semiconductor laser is________________.	direct pumping	optical pumping
The wavelength of the laser beam emitted by a semiconductor laser depends on ________________.	biasing voltage across the junctions	band gap
Due to ____________________ property laser is used to destroy tumors.	highly intense	directionality
Due to __________________ property laser is used to do micro surgery.	highly intense	directionaliy
Due to __________________ property, laser is used in endoscopic applications.	directionality	high penetrating power
The term "monochromatic" means__________________.	inphase	single wavelength
The term "coherence" means________________.	inphase with same frequency	single wavelength
Which of following parameter induces the lasing action?	spontaneous emission	stimulated emission
The angular spread at ordinary light is_______________.	1mm/m	1m/m
Spontaneous emission is random and ________________________	dependent of incident radiation	independent of incident radiation
Under________________the population of energy levels obey the Boltzmann's distribution law.	low temperature	high pressure
Spontaneously emitted photons are____________________	inphase	not inphase
In stimulated emission, the emitted photons are________________	not inphase	random in direction

The medium in which the population inversion takes place.	active centre	active medium
A photon incident on the excited atoms in the active medium and initiates the ___________________	absorption	stimulated emission
The atoms in the active medium are allowed to go from ground state to excited state, the ____________________ is achieved.	laser action	normal population
The more number of atoms stimulated from excited state to the ground state ___________________is achieved.	laser action	population inversion
Brewster windows produces the ___________________by reflection, of perpendicularly polarized light.	population inversion	plane polarised light
The output nature of Carbon dioxide laser is ___________________	continuous	pulsed
The output power of the Carbon dioxide laser is increased by ________________	increasing the diameter of the discharge tube	decreasing the diameter of the discharge tube
The band gap energy of the homojunction semiconductor laser is ____________________	1.55eV	1.44MeV
The band gap energy of the hetrojunction semiconductor laser is ___________________	1.55eV	1.44MeV
Due to___________________property the laser is used in drilling process.	directionality	highly intense
The output power of the Ga-As laser is_________________.	1.8W	1.8mW
Which carrier wave is capable of carrying more information's?	Radio waves	microwaves
The central portion of optical fiber consists of ____________________.	Cladding	core
The refractive index of the core is ___________________than cladding surface of optical fiber.	Greater	below
Polyurethane is used as ___________________.	strengthing material	strengthing material
____________________ layer traps the escaping light from the core.	Outer jacket	strengthing material
The optical fibers has____________ band width.	High	low
The optical fibers has _________________ loss.	Maximum	minimum
The principle of optical fiber communication is_________________.	Refraction	diffraction
The diameter of the core in single mode fibers are _______________ multi mode fibers.	Smaller than	larger than

The band width of single mode fiber is _______________.	more than 50 MHz Km	less than 50MHz Km
In general the single mode fibers are _______________ fibers.	Step index	graded index
The path of light propagation in graded index fiber is ______________.	Zigzag	helical
In photodiode, the electron hole pair is created due to the ___________ of photon.	Emission	absorption
The unit of Numerical Aperture is ___________________.	No unit	decibel
________________ communication can be made even in the absence of power.	Radio wave	microwave
In the fiber communication, the optical signals are _______________ by electric signals, (lightening).	Affected	not affected

opt3	opt4	opt5	opt6	answer
1014KHZ	1014HZ			1014HZ
1mm/m	1cm/m			1mm/m
monochromatic in nature	monochromatic,coherent in nature			monochromatic,coherent in nature
laser light beam	monochromatic light beam			laser light beam
less intense &incoherent	monochromatic & coherent			less intense &incoherent
low pressure	high temperature			negative temperature
direct conversion	chemical method			direct electron excitation
Carbon dioxide	mixture of Carbon dioxide and nitrogen			Carbon dioxide
P-type semi conductor	N-type semiconductor			P-N junction diode
silicon	recombination of electrons and holes			recombination of electrons and holes
6382 A	6485 A			8400A-8600A
P-N junction	polished-junction of diodes			polished-junction of diodes
high conductivity	high reflecting property			high refractive index
inelastic collision	direct pumping			optical pumping
1.06 A	8000 A			8000 A
5892 A	8626 A			8626 A

8626 A	8014 A	8014 A
chemical pumping	elastic collision	direct pumping
the concentration of donar and acceptor atoms in an active medium	band gap and the concentration of donor and acceptor atoms in an active medium	band gap and the concentration of donor and acceptor atoms in an active medium
high penetrating power	not absorbed by water	high penetrating power
high penetrating power	not absorbed by water	directionaliy
highly intense	narrow band width	highly intense
directional	intense	single wavelength
intense	less angular spread’	inphase with same frequency
stimulated absorption	spontaneous absorption	stimulated emission
1cm/m	10^{-3}m/m	1m/m
frequency of incident radiation	intensity of incident radiation	independent of incident radiation
high temperature	thermal equilibrium	thermal equilibrium
incoherent	not inphase and incoherent	not inphase and incoherent
highly coherent and monochromatic	polychromatic	highly coherent and monochromatic

optical resonator	vacuum	active medium
spontaneous emission	stimulated and spontaneous emission	stimulated emission
population inversion	pumping	population inversion
spontaneous emission	pumping	laser action
un polarised light	pumping	plane polarised light
continuous & pulsed	continuous(or)pulsed	continuous(or)pulsed
increasing the pressure of active medium	increasing the pressure of active centre	increasing the diameter of the discharge tube
1.44eV	1.55MeV	1.44eV
1.44eV	1.55MeV	1.55eV
narrow band width	high penetrating power	high penetrating power
1mW	1W	1mW
light waves	sound waves	light waves
strengthing material	outer jacket	core
similar	dissimilar	Greater
outer jacket	core	outer jacket
cladding	core	Outer jacket
zero	very narrow	High
zero	1	minimum
total internal reflection	reflection	total internal reflection
same as	non-linear with respect to	Smaller than

less than 50KHz Km	Less than 50 KHz Km.	more than 50 MHz Km
Step & graded index	either step (or) graded index	Step index
circle	straight line	helical
both emission and absorption	interference	absorption
meter	Hz	No unit
optical wave	matter wave	optical wave
slightly affected	transmitted	not affected

questions	opt1	opt2
The boundary separating the two adjacent grains is called ________________	crystal	x-rays
The example of amorphous solids is ___________	plastic	nickel
The example of crystalline solids is ______________	gold	rubber
Crystalline material is _______________	anisotrophic	isostrophic
Non crystalline material is _________________	anisotropic	isotropic
The lattice means__________	imaginary concept	real concept
Space lattice is _________________	3-dimensional	2-dimensional
The example of basis is _________________	aluminium	platinium
The crystal structure is ________________	lattice+basis	basis+molecule
The unit cell is _____________.	smallest geometric figure	largest geometric figure
The primitive cell is _________________	one lattice point	two lattice point
The example of primitive cell is _______________	SC	BCC
The crystal system is ________________	7	8
The crystal parameters of triclinic crystal system is ____________________	a≠b≠c	a≠b=c
The lattice parameters of monoclinic crystal system is __________________	a≠b≠c	a≠b≠c
The lattice parameters of orthorhombic crystal system is _______________	α=β=γ=900	α ≠ β= γ=900
The lattice parameters of tetragonal crystal system is ________	a=b≠c	a≠b≠c
The lattice parameters of hexagonal crystal system is _____________	α= β =900	α ≠ β ≠ 900
The number of Bravais lattice of triclinic system is __________________	1	2
The number of Bravais lattice of monoclinic system is _________	1	2
The number of Bravais lattice of terragonal system is _________________	2	1
The number of Bravais lattice of hexagonal system is _________________	1	2
The number of Bravais lattice of trigonal system is _______________	1	2
The number of Bravais lattice of cubic system is ________________	3	2
The number of Bravais lattice is _________________	4	7

The total number of atoms present in (or)shared by an atoms is called_____________	effective number	atomic radius
________________ is the number of nearest neighbouring atoms to a particular atom.	atomic number	atomic mass
Atomic packing factor is ________________	v/V	V/v
The total number of atoms per unit cell in SC is ______________	2	1
The total number of atoms per unit cell in BCC is ____________________	1	3
The total number of face centre atoms per unit cell in FCC is _________________	2	1
The total number of atoms per unit cell in FCC is _______________	1	2
The number of body centre atoms per unit cell is ________________	4	3
The atomic radius of SC structure is _______________	a/2	a/4
The atomic radius of BCC structure is __________________	a/2	a/4
The atomic radius of FCC structure is _______________	a/2	a/4
The co-ordination of SC structure is __________________	4	2
The co-ordination number of BCC structure is _________________	4	6
The co-ordination number of the FCC structure is __________________	10	12
Atomic packing factor for BCC structure is _______________	0.68	0.78
The APF for SC structure is ______________	0.68	0.78
The APF of FCC structure is ________________	0.68	0.78
The volume of 1 atom is ______________	4/3πr2	4/3 πr3
The number of atoms per unit cell in hexagonal _____________	12	8
The co-ordination number of hexagonal structure is _________________	12	8
The atomic radius of HCP structure is _________________	a/2	a/4
The APF of HCP structure is _________________	0.68	0.74
The total number of diamond cubic structure is ________________	4	6
The total number of atoms present in (or)shared by an atoms is called_____________	effective number	atomic radius
An element that can exist in 2 or more forms in the same state is called _______________	polymorphism	allotrophy

If the atoms in the solid are not arranged in a perfectly regular manner, it is called________	crystal point	crystal defect
The point defect is ___________	schottky defect	grain boundaries
The line defect is _____________	schottky defect	grain boundaries
The surface defect is ___________	schottky defect	edge discolation
The defect which take place due to imperfect packing of atoms during crystallization are known as ________	line defect	crystal defect

opt3	opt4	opt5	opt6	answer
grain boundary	crystallography			grain boundary
platinum	silver			plastic
glass	plastic			gold
sharp melting point	definite geometrical shape			anisotrophic
regular geometrical shapes	isochoric			isotropic
regular concept	lattice concept			imaginary concept
1-dimensional	4-dimensional			3-dimensional
aluminium	Nacl			aluminium
lattice+atoms	basis+atoms			lattice+basis
middle geometric figure	very largest geometric figure			smallest geometric figure
three lattice point	four lattice point			one lattice point
FCC	triclinic			SC
6	5			7
a=b≠c	a=b=c			a≠b≠c
a=b=c	a=b≠c			a≠b≠c
α= β≠ γ=900	α≠ β≠ γ≠900			α=β=γ=900
a=b=c	a≠b=c			a=b≠c
α ≠ β = 900	α = β ≠900			α= β =900
3	4			1
3	4			2
3	4			2
3	4			1
3	4			1
4	1			3
14	3			14

co-ordinations number	cubic system	effective number
atomic weight	co-ordination number ans-d	co-ordination number ans-d
v/ ρ	V/ρ	v/V
3	4	1
4	2	2
3	6	3
3	4	4
2	1	1
a/6	a/8	a/2
a * sqrt(3)/4	a/8	a * sqrt(3)/4
a * sqrt(2)/4	a/8	a * sqrt(2)/4
3	6	6
8	10	8
14	8	12
0.74	0.52	0.68
0.74	0.52	0.52
0.74	0.52	0.74
4/ πr2	4/ πr3	4/3 πr3
6	4	6
6	4	12
a/6	a/8	a/2
0.72	0.52	0.74
8	10	8
co-ordinations number	cubic system	effective number
crystal	SC	allotrophy

BCC	FCC	crystal defect
edge dislocation	screw dislocation	schottky defect
edge discolation	frenkel defect	edge discolation
grain boundaries	frenkel defect	grain boundaries
point defect	surface defect	point defect