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CODE &SUBJECT :PH6151 & ENGINEERING PHYSICS I
UNIT – I CRYSTAL PHYSICS
PART - A

1. What is a space lattice?

Space lattice is an infinite arrangement of points in three dimensions in which every point has an identical surrounding.

2. Name seven crystal systems.

i. Cubic ii. Tetragonal iii. Orthorhombic iv. Monoclinic v. Triclinic vi. Rhombohedral vii. Hexagonal

3. Give the values of number of atoms in unit cell of SC, BCC, FCC & HCP.

Type of Structure	Number of atoms in Unit cell
Simple Cubic	1
Body Centered Cubic	2
Face Centered Cubic	4
Hexagonal	6

4. Define coordination number.

Coordination number is the number of nearest neighbouring atoms that an atom has in the given crystal structure.

5. What are the coordination numbers in SC, BCC, FCC & HCP?

Type of Structure	Coordination Number
Simple Cubic	6
Body Centered Cubic	8
Face Centered Cubic	12
Hexagonal	12

6. Define atomic radius.

Half the distance between the nearest neighboring atoms in a crystal is known as atomic radius. It is denoted by ‘r’ and is usually expressed in terms of the cube edge ‘a’.

7. Obtain the formula for atomic radius ‘r’ in terms of lattice constant ‘a’ for simple cubic structure.

In the simple cubic structure:

$2r= a; \quad r=a/2$

8. Arrive at an expression for atomic radius in terms of lattice constant for BCC structure.

For BCC structure:

$r+2r+r=a\sqrt{3} \quad ; \quad 4r=a\sqrt{3} \quad ; \quad r= a\sqrt{3}/4$

9. Arrive at an expression for atomic radius in terms of lattice constant for FCC structure.

For FCC structure:

$r+2r+r=a\sqrt{2} \quad ; \quad 4r= a\sqrt{2} \quad ; \quad r=a\sqrt{2}/4=a/\sqrt{2}$

10. What is a primitive cell?

Primitive cell consists of only one atom per unit cell.

11. Define atomic packing factor. Write its unit.

Packing factor is the ratio of the volume of atoms in the unit cell to the volume of the unit cell. There is no unit for it since it is a ratio.

12. Calculate the packing factor in SC structure.

Packing factor (P.F) = Volume occupied by the atoms in a unit cell/ volume of unit cell

$$= \frac{1\times\frac{4}{3}\pi r^3}{a^3}$$

For SC, r=a/2; a=2r P.F = $\frac{1\times\frac{4}{3}\pi r^3}{(2r)^3} = \frac{\pi}{6}$ =52%

13. Calculate the packing factor in BCC structure.

Packing factor (P.F) = Volume occupied by the atoms in a unit cell/ volume of unit cell

$$= \frac{2\times\frac{4}{3}\pi r^3}{(a)^3} \quad (n=2)$$

For BCC: r= a√3/4; a=4r/√3

$$\text{P.F} = \frac{2\times\frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{3}}\right)^3} = \frac{3\pi}{8} = 68\%$$

14. Calculate the packing factor in FCC structure.

Packing factor (P.F) = Volume occupied by the atoms in a unit cell/ volume of unit cell

For FCC: r= a√2/4; a=4r/√2

$$\text{P.F} = \frac{4\times\frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{2}}\right)^3} = \frac{\sqrt{2}\pi}{6} = 74\%$$

15. State c/a ratio and packing factor of HCP.

$\frac{c}{a} = \sqrt{\frac{8}{3}} = 1.633;$ Packing factor = $\frac{\pi}{3\sqrt{2}}$ = 74%

16. What are Miller indices?

Miller indices are three possible integers that have the same ratio as the reciprocals of the intercepts of the plane concerned on the three axes.

17. Define unit cell.

A unit cell is the smallest unit which, when repeated in space indefinitely, will generate the space lattice.

18. What are Bravais lattices?

According to Bravais, there are 14 possible types of space lattices out of seven crystal systems. These 14 space lattices are called Bravais lattices.

19. Write the expression for inter-planar spacing for a cubic system in terms of lattice constant and Miller indices.

Inter planar spacing $d = \frac{a}{\sqrt{(h^2+k^2+l^2)}}$.

a=lattice constant, h k l= Miller indices.

20. What are the lattice parameters of an unit cell?

The characteristic intercepts on the axes a, b& c and interfacial angles α, β and γ are the lattice parameters of an unit cell.

21. What is the relation between lattice constant 'a' and density ' ρ' of the crystal.

$$a = \left(\frac{nM}{\rho N}\right)^{\frac{1}{3}}$$

22. What are the differences between crystalline and non crystalline material?

Crystalline material	Non-crystalline material
They have a definite and regular geometrical shapes which extend throughout the crystal	They don't have definite geometrical shape
They are anisotropic	They are isotropic
They are most stable	They are less stable
Example: NaCl, KCl	Example: Plastic, glass, rubber

23. A unit cell has the dimensions a=b=c = 4.74 Å and $\alpha = \beta = \gamma = 60^0$. What is the crystal structure?(Jan 2012)

Rhombohedral or trigonal structure as a=b=c and $\alpha = \beta = \gamma \neq 90^o$.

24. What are crystalline materials? Give example.

Crystalline materials are materials in which the atoms are arranged in an orderly fashion throughout in a three dimensional pattern. Example: copper, silver.

25. What is an amorphous solid?

It is a type of solid in which the atoms are not arranged in an orderly fashion.

26. What is a crystal?

A crystal is a three dimensional solid composed of a periodic and regular arrangement of atoms.

27. What is a basis?

The crystal structure is formed by associating with every lattice point a unit assembly of atoms or molecules (i.e., one or more atoms or molecules). This unit assembly is called the basis or pattern.

28. What is meant by loosely packed crystal structure? Give an example of this type of material.

A loosely packed crystal structure has low packing factor that is, in which more vacant sites are available. Simple cubic polonium has loosely packed crystal structure.

29. What is meant by closely packed structure? Give one example for this.

Closely packed structure has the highest packing factor of 0.74. Here the atoms are closely packed leaving a small space as vacant site in the crystal. Face centered cubic copper and hexagonal close packed magnesium are examples of this closely packed structure.

30. What is diamond structure?

Germanium, Silicon and diamond possess a structure which is a combination of two interpenetrating FCC sub lattices along the body diagonal by ¼ th of cube edge.

31. What is graphite structure?

In this graphite structure, carbon atoms are arranged in regular hexagon in flat parallel layers such that each atom is linked by the neighbouring atoms. However there is no strong bonding between different layers which are therefore easily separable from each other.

32. Mention the various crystal growing techniques.

i. Melt growth ii. Low temperature solution growth
iii. High temperature solution growth (Flux growth) iv. Epitaxial growth.

33. What is melt growth?

Melt growth is a process of crystallization by fusion and resolidification of the starting materials.

34. What are the major practical factors to be considered during the growth of crystals from melt?

i. Volatility ii. Chemical reactivity and iii. Melting point

35. What is the basic principle of Czochralski method of growing crystal?

The Czochralski method is a crystal pulling technique from the melt and it is based on a liquid solid phase transition driven by a seed crystal in contact with the melt.

36. What are the advantages of Czochralski method?

i. Growth from free surface
ii. Growth of large oriented single crystals
iii. Convenient chemical composition
iv. Control of atmosphere

37. What are the limitations of Czochralski method?

i. High vapour pressure materials

ii. Liquid phase encapsulation
iii. Possible contamination of the melt by the crucible.
iv. No reproductivity of the crystal shape.

38. What is the basic principle of Bridgman technique?

A common technique of growing single crystals involves selective cooling from the molten materials, so that solidification occurs along the crystal direction. In this technique, the melt in a sealed crucible is progressively frozen from one end.

39. What are the advantages of Bridgman technique?

i. Simple technique
ii. Controls over vapor pressure
iii. Containers can be evacuated and sealed
iv. Control of shape and size of growing crystals
v. Stabilization of thermal gradients.

40. What are the limitations of Bridgman technique?

i. Confinement of crystals.
ii. Crystal perfection is not better than that of the seed.
iii. No visibility

41. What is the basic principle of slow evaporation method?

In this method, the saturated solution is kept at a particular temperature and provision is made for evaporation.

42. What are the advantages of slow evaporation method?

i. This is simple and convenient method of growing single crystals of large size.
ii. Growth of strain and dislocation free crystals.
iii. Permits the growth of prismatic crystals by varying the growth conditions.
iv. Only method which can be used for substances that undergo decomposition before melting.
v. A variable rate of evaporation may affect the quality of the crystal.

43. What are the disadvantages of slow evaporation method?

i. The growth substance should not react with the solvent.
ii. This method is applicable for substances fairly soluble in a solvent.

44. What is Epitaxial growth?

The process of growing an oriented single crystal layer on a substrate wafer is called epitaxial growth.

45. What is the application of epitaxial growth?

This method is mainly used in the manufacture of LED's and detectors.

46. What are different types of epitaxial growth?

i. Vapour Phase Epitaxy (VPE)
ii. Liquid Phase Epitaxy (LPE)
iii. Molecular Beam Epitaxy (MBE)

PART-B

1. What are lattice parameters of a unit cell? Define the terms atomic radius and packing factor. Calculate the above for SC, BCC and FCC Structures.
2. What is packing factor? Prove that the packing factor of HCP is 0.74.
3. (a) What are Miler Indices? Explain how they are determined with any two planes in SC structure. Give their significance.
   (b) The lattice constant for a unit cell of aluminum is 4.049Å. Calculate the spacing of (220) plane.
4. i. Sketch two successive (110) plane.
   ii. Show that for a cubic lattice, the distance between two successive planes (h k l) is given by $d= a/\sqrt{(h^2+k^2+l^2)}$.
5. Show that in a simple cubic lattice the separation between the Successive lattice planes (100), (110) and (111) are in the ratio of 1:0.71:0.58.
6. (a) Describe the structure of Diamond and graphite

(b) Copper has FCC structure and its atomic radius is 1.273Å. Find (i) lattice parameter (ii) Density of copper. Atomic weight of copper = 63.5, Avogadro's number = 6.023×10^{23}.

7. Describe Bravais lattices of the seven crystal systems with neat diagrams.

8. (a) Explain the various types of crystal systems with a neat sketch and example.

   (b) i. Zinc has HCP structure. The height of the unit cell is 0.494nm. The nearest neighbouring distance is 0.27nm. The atomic weight of Zinc is 65.37g. Calculate the volume of the unit cell and density of Zinc.

   ii. Calculate the number of atoms per square meter on the planes (100), (110) and (111) for a simple cubic lattice built of spherical atom of radius R.

9. Explain any two crystal growing techniques.

10. Describe Bridgman method of growing crystal. Mention the merits and demerits.

11. Describe the solution growth of crystal and list out its advantages and disadvantages.

12. Explain the vapour growth technique of growing crystals.

13. Explain the Czochralski method of growing crystals. Mention the merits and demerits.

UNIT II - PROPERTIES OF MATTER AND THERMAL PHYSICS

PART - A

1. What is elasticity?

The property of the body to regain its original shape or size, after the removal of deforming force is called elasticity.

2. What are elastic bodies?

Bodies which regain its original shape or size after the removal of deforming force are called elastic bodies. Ex: Quartz.

3. Define stress and its unit.

The restoring or recovering force per unit area set up inside 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 deforming force applied per unit area of the body.

Stress = deforming force/area = F/A (N/m^2)

S.I unit of force is Newton (N) and that of area is $meter^2$

4. What are the different types of stress?

It is found that a deforming force may change the length or the shape of the body or the volume. Accordingly, there are three types of stress namely (i) Longitudinal or normal stress (ii) shearing or tangential stress (iii) volume or compressive stress.

5. Define strain and its unit.

The change in dimension or shape of a body due to deforming force is called strain.

Strain = Change in dimension/Original dimension

6. What are the types of strain?

According to the changes that take place in length, area and volume there are three types of strain namely linear strain, shearing strain and volume strain

7. Define Hooke's law.

Within elastic limit, the stress is directly proportional to strain.

Stress α strain : Stress/ strain = E where E is called Modulus of elasticity.

8. Mention the three different Modulii of elasticity

There are three types of modulii of elasticity corresponding to three types of strains.

They are
1. Young's modulus of elasticity, corresponding to longitudinal strain.
2. Rigidity modulus or shear modulus corresponding to shearing strain.
3. Bulk modulus or volume modulus corresponding to volume strain.

9. Define Young's modulus of elasticity.

Within the elastic limit, the ratio of longitudinal stress to longitudinal strain is called the Young's modulus of elasticity. Y = Longitudinal stress/Longitudinal strain $= \frac{F/A}{l/L} = \frac{FL}{Al}$ unit: N/m^2

10. Define Rigidity modulus.

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

η = Tangential stress/Shearing strain = $\frac{F/A}{\phi} = \frac{T}{\phi}$ where T is Tangential stress

11. Define Bulk modulus.

Within the elastic limit of a body, the ratio of the volume stress to the volume strain is called bulk modulus. K = Volume stress/Volume strain = $\frac{F/A}{v/V} = \frac{FV}{Av}$

12. Define Poisson's ratio.

The ratio of Lateral strain (β) to the Linear strain (α) is called as Poisson's ratio.

Poisson ratio $\sigma = \frac{\beta}{\alpha}$

13. Write the relation between the elastic moduli.

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

Where E is Young's modulus, n is Rigidity modulus and K is Bulk modulus.

14. Define the term lateral strain?

The ratio of change in diameter of the wire to the original diameter of the wire is known as lateral strain.

15. Define the term linear strain?

The ratio of change in length of the wire to the original length is known as linear strain.

16. What is the use of stress-strain diagram?

The behavior of solid materials is obtained by using this stress strain diagram.

17. What are the factors affecting elasticity?

i. Change in temperature ii. Effect of hammering and rolling iii.Effect of annealing
iv. Effect of impurities

18. How temperature affects elasticity?

Increase in temperature reduces the elastic property. For example, carbon filament is elastic in nature at room temperature but it is converted into plastic state when it is heated.

19. What are elastic materials?

Materials which recover their original state after removal of the deforming force are called perfectly elastic materials.

20. What are plastic materials?

Materials which do not recover their original state even after removal of the deforming force are called as plastic materials.

21. Write the relation between Y & K and explain the various term.

$K = \frac{Y}{3(1-2\sigma)}$ Where Y is Young's modulus, K is Bulk modulus & σ is Poisson ratio

22. Write the relation between Y & n and explain the various term.

$n = \frac{Y}{2(1+\sigma)}$ Where Y is Young's modulus, n is Rigidity modulus & σ is Poisson ratio

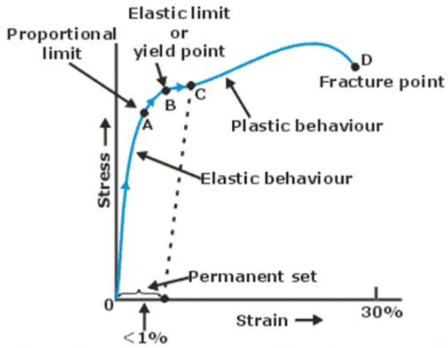
23. What is a beam?

A beam is a rod or bar of uniform cross section whose length is very much greater than its thickness.

24. Define neutral surface and neutral axis.

In the middle of the beam, there is a layer which is not elongated or compressed due to bending of the beam, this layer is called neutral surface and the line at which the neutral layer intersects the plane of bending is called the neutral axis.

25. Draw the stress-strain curve.



A typical stress-strain curve for a ductile metal

26. What is uniform bending in Cantilever?

A beam is supported at the ends and equal load is applied at the ends and the bending of beam describes an arc of a circle.

27. What is a cantilever?

A beam fixed horizontal at one end and loaded at the other end is called a cantilever.

28. What is meant by bending of beam?

A beam is a rod or a bar of uniform cross-section, whose length is very large to the other dimensions, so that the shearing stress at any point of the rod is very small and negligible.

29. What is non-uniform bending in Cantilever?

A beam is supported at the ends and equal load is applied at the centre and the bending of beam does not describe an arc of a circle.

30. What is an I-shaped 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.

31. What are the advantages of I shape girders?

i. As the layers of the beam at the top and bottom are subjected to maximum stress more material is needed there to withstand the strain.

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

iii. I form of girders are made of steel as it has high Young modulus.

32. A copper wire of 3m length and 1mm diameter is subjected to a tension of 5 N. Calculate the elongation produced in the wire if the Young's modulus of elasticity of copper is 120 GPa.

$$Y = \frac{FL}{Al} \quad l = \frac{FL}{AY} = \frac{5 \times 3}{120 \times 10^9 \times 3.14 \times \left(0.5 \times 10^{-3}\right)^2} = 1.592 \times 10^{-4}\, m$$

33. A wire, 3m long and 6.25 x10^{-5} m^2 in cross – section is found to stretch 3 x 10^{-3} m under a tension of 1.2 x 10^3 N. What is the Young's modulus of the material of the wire?

$$Y = \frac{FL}{Al} = \frac{1.2 \times 10^3 \times 3}{6.25 \times 10^{-5} \times 3 \times 10^{-3}} = 1.92 \times 10^{10} \text{ Nm}^{-2}$$

34. A steel wire of length 2.75 m and having diameter 1 X 10^{-3} m is attached to a beam in its upper end. If a load of 1 Kg is suspended from the lower end, how much will the wire be extended? (Young's modulus = $2x10^{11}$ Nm^{-2})

T = Mg ; Substituting g and M value in the above equation, T = 1 x 9.8 N; Tension T = 9.8N

$$Y = \frac{FL}{Al} \quad l = \frac{FL}{AY} = \frac{9.8 \times 2.57}{2 \times 10^{11} \times 3.14 \times \left(0.5 \times 10^{-3}\right)^2} = 1.71569 \times 10^{-4}\, m$$

35. Show that the rigidity modulus n and Young's modulus Y are connected by the relation,

$$n = \frac{Y}{2(1+\sigma)}$$ where σ is the Poisson's ratio.

(a). The relation between K and α can be written as,

$$K = \frac{1}{3(\alpha - 2\beta)} = \frac{\frac{1}{\alpha}}{3\left(1 - \frac{2\beta}{\alpha}\right)}$$

Substituting the values of Y and σ in above equation, we get, $K = \frac{1}{3(\alpha - 2\beta)}$

(b). The relation between n and α can be written as,

$$n = \frac{l}{2(\alpha + \beta)} = \frac{Y}{2(1-\sigma)}$$ Where $Y = \frac{1}{\alpha}$ and $\sigma = \frac{\beta}{\alpha}$

36. Calculate the work done in stretching a wire of length 1 m and of diameter 1 mm by 5 cm.

Young's modulus of the material of the wire is 1 x 10^{11}pascal.

Stress = Young's modulus x Strain

Work done per unit volume in stretching a wire = ½ x stress x strain

Therefore, work done= ½ x stress x strain x volume of the wire

$$= \frac{1}{2} \times 1 \times 10^{11} \times \left(\frac{5 \times 10^{-2}}{1}\right)^2 \times 3.14 \times \left(0.5 \times 10^{-3}\right)^2 \times 1 = 98.125\, Joules$$

37. A copper wire of length 3m and 1mm diameter is subjected to a tension of 5 kg weight. Calculate the elongation produced in the wire if the Young's modulus of elasticity of copper is 120 GPa.

$$Y = \frac{FL}{Al} \text{ or } l = \frac{FL}{AY}$$

Increase in length = $\frac{5 \times 9.8 \times 3}{3.14 \times \left(0.5 \times 10^{-3}\right)^2 \times 120 \times 10^9} = 1.56 \times 10^{-3}\, m$

38. Define heat conduction.

Conduction is the process of transmission of heat from one point to another through substance without the actual motion of the particles. Conduction always requires some material medium. The material medium may be solid, liquid, gas. Ex: By heating one end of the rod, the heat is transmitted to the other end.

39. Define the coefficient of thermal conductivity.

The ability of a substance to conduct heat energy is called its thermal conductivity. The coefficient of thermal conductivity of a material is defined as the heat conducted per second normally across unit area of cross section of the material per unit temperature gradient.

$$K = \frac{Qx}{A(\theta_1 - \theta_2)t}$$ Unit: Watts/metre /Kelvin

40. What is steady state?

When a solid bar is heated at one end, each particle absorbs some heat, raises its own temperature and loses a little heat by radiation and transmits the rest to the next, a stage is reached when each particle has taken its full and cannot absorb any more heat.

41. Derive the unit in which thermal conductivity is measured.

$$K = \frac{Qx}{A(\theta_1 - \theta_2)t}$$ Unit: Watts/metre/Kelvin

42. Define Newton's law of cooling.

It states that the rate at which a body loses heat is directly proportional to the temperature difference between the body and that of the surroundings. The amount of heat radiated depends upon the area and nature of the radiating surface.

43. What are the limitations of Newton's law of cooling?

i. The temperature difference between the hot body and surrounding should be low.
ii. The heat loss is only by radiation and convection
iii. The temperature of the hot body should be uniform throughout.

44. What are the uses of Newton's law of cooling?

The specific heat capacity of a liquid is determined by using Newton's law of cooling.

45. What is thermal resistance?

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

46. What is Radial flow of heat?

In this method, the heat will flow from the inner side towards the other side along the radius of the spherical shell or cylindrical shell. This method is interesting because there is no loss of heat as in the other methods.

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

Good conductors	Bad conductors
They have high electrical and thermal conductivity	They have low electrical and thermal conductivity
They can be easily heated or cooled	They cannot be easily heated or cooled
Ex: Metals like iron, copper	Glass ,wood

48. How are heat conduction and electrical conduction analogous to each other? (Dec 2008)

Heat conduction	Electrical conduction
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
In metals heat conduction is mainly due to free electrons	In metals electrical conduction is due to free charge carriers namely electrons.
The ability to conduct heat is measured by thermal conductivity.	The ability to conduct electricity is measured by Electrical conductivity.

49. 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.

50. When ice forms in a lake, where will it start? In which direction will it grow?

When the temperature of cold air above the lake water is below 0°C, ice is formed on the lake. It will start from the upper surface of the lake, it will grow from top surface to bottom surface of lake.

51. What is the 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 and is placed in between the Lee's disc and steam chamber. The steam is passed through bad conductor. Heat conducted through the bad conductor per second is calculated. Amount of heat lost per second by the disc is also calculated. At steady state heat conducted through the bad conductor per sec = Amount of heat lost per sec by the disc. From this, thermal conductivity of the bad conductor is calculated.

52. How much heat will be conducted through a slab of area 90×10^{-4} m^2 and thickness 1.2 x 10^{-3}m in one sec? When its opposite faces are maintained at temperature difference of 20 K. The coefficient of thermal conductivity of that material is 0.04 $Wm^{-1} K^{-1}$

Amount of heat conducted $Q = \frac{KA(\theta_1 - \theta_2)t}{x}$

$$= \frac{0.04 \times 90 \times 10^{-4} \times 20 \times 1}{1.2 \times 10^{-3}}$$

= 6 Joules

53. A rod 0.25 m long and 0.892 x 10^{-4} m^2 area of cross section is heated at one end through 393 K while the other end is kept at 323 K. The quantity of heat which will flow in 15 min. along the rod is 8.811 x 10^3 joules. Calculate thermal conductivity of the rod.

$$K = \frac{Qx}{A(\theta_1 - \theta_2)t}$$

$$K = \frac{8.811 \times 10^3 \times 0.25}{0.892 \times 10^{-4} \times 70 \times 900}$$

K = 392 Watts/metre/Kelvin

54. A 20cm length iron rod is heated at one end to 100°C, while the other end is kept at a temperature of 30°C. The area of cross section of the iron rod is 0.685cm^2. Assume that the iron rod is thermally insulated. Calculate the amount of heat conducted through the rod in 10 minutes along the way. Given the thermal conductivity of the iron K = 62 $Wm^{-1}K^{-1}$.

$$Q = \frac{KA(\theta_1 - \theta_2)t}{x} = \frac{62 \times 0.685 \times 10^{-4} \times (373 - 303) \times 600}{0.2} = 891.87 \text{ J}$$

The iron rod conducts 891.87 J of energy in 10 minutes.

55. A cantilever of rectangular cross section has a length of 50 cm its breadth is 3 cm and thickness 0.6 cm if a weight of 1Kg is attached at the free end the depression produced is 4.2 cm calculate the young's modulus of the material of the bar.

$$Y = \frac{4Mgl^3}{bd^3y} = 1.8 \times 10^{10} \text{ N/m}^2$$

56. Uniform rectangular bar 1 m long, 2cm broad and 0.5 cm thick is supported on its flat face symmetrically on two knife edges 70cm apart. If loads of 200g are hung from the two ends find the elevation of the center of the bar, Young's modulus of the material of the bar is 18 x10^{10}Pa.

$$y = \frac{3Mgal^2}{2bd^3Y} = 1.8 \times 10^{10} = 4.802 \text{ x}10^{-4}\text{m.}$$

PART B

1. Drive an expression for the elevation at the centre of a beam which is loaded at both ends. Describe an experiment to determine Young's modulus of a beam by uniform bending.
2. Give the theory of the loaded cantilever. Using the above theory, describe the experimental method to find the Young's modulus of the material.
3. Drive an expression for the depression of a cantilever fixed at one end horizontally and loaded at the free end.
4. Explain stress strain diagrams. Discuss the factors affecting the elasticity of a material.
5. Write an essay about the elastic behavior of materials.
6. What are the different types of elastic modulii? Derive the necessary mathematical relation.
7. Derive an expression for the internal bending moment of a beam in terms of radius of curvature.

(i) What is cantilever?
(ii) Drive an expression to find the depression in a cantilever fixed at one end and loaded at the other end.
(iii) Describe an experimental method used to find the Young's modulus of a cantilever.

9. Describe with relevant theory the method of determining the coefficient of thermal conductivity of a bad conductor by Lee's method.
10. (i) What is uniform bending?

(ii) Drive an expression for depression for a rectangular beam loaded in such a way that the bending is uniform.

(ii) Describe an experimental method used to find the Young's modulus of a rectangular bar loaded in uniform bending.

11. A cantilever of length 50cm fixed at one end is depressed by 20mm at the loaded end. Calculate the depression at a distance of 40cm from the fixed end.
12. Derive the equation for one dimensional flow of heat and solve it, under steady state condition.

13. Describe methods of determining thermal conductivity of rubber.
14. Describe with relevant theory the method of determining the coefficient of thermal conductivity of a bad conductor by Lee's method.
15. Derive an expression for thermal conductivity of the material of a thick pipe through which a hot liquid is flowing.
16. Deduce a mathematical expression for one dimensional heat flow.
17. Explain the following processes:
    (i) Formation of ice on ponds, and
    (ii) Thermal conduction in a compound medium.
18. Explain the experimental method used to determine the thermal conductivity of rubber based on the principle of radial flow of heat
19. A solid of square of side 50cm and thickness 10cm is in contact with steam at 100ºC on one side. A block of ice at 0ºC rests on the other side of the solid 5Kg of ice is melted in 1 hour. Calculate the thermal conductivity of the solid**.**
20. A composite metal bar of uniform cross section is made up of 0.25 m of metal A and 0.1 m of metal B and each being in perfect thermal contact with the adjoining part. There is no heat loss at this sites.The thermal conductivities of metals A and B are 920 and 140 S.I. units respectively. The end A is maintained at 100^0C and the end B is maintained at 24^0C. Calculate the temperature at A – B junction.

UNIT III - ACOUSTICS AND ULTRASONICS

PART - A

1. What are the factors affecting the acoustical quality of a building.

a) Reverberation time b) Focusing and interference c) Echoes and Echelon effect
d) Resonance and e) Extraneous noise

2. If the reverberation time is lower than the critical value, how will it affect the acoustical quality of building?

When the reverberation time is lower than the critical value, sound becomes inaudible by the observer and the sound is said to be dead and if the reverberation time is too large, echoes are produced. Therefore, the reverberation time should have some optimum value.

3. Define reverberation time of an auditorium.

The persistence of audible sound, even after the source has stopped to emit the sound is called reverberation. The time during which the sound persists in the hall is called as reverberation time.

4. Define absorption coefficient of a material.

The absorption coefficient of a material is defined as the ratio of the sound energy absorbed by the surface to that of the total sound energy incident on the surface.

$$\text{Absorption coefficient (a)} = \frac{\text{Sound energy adsorbed by the surface}}{\text{Total sound energy incident on the surface}}$$

The absorption coefficient can also be defined as the rate of sound energy absorbed by a certain area of surface to that of an open window of same area.

5. Write a note on noise pollution.

Noise pollution is one of the major factors which occur in our day to day life. The noise produced in a particular area creates harmful effects to the human being. It produces mental fatigue and irritation. It diverts our concentration on work hence reduces the efficiency and quality of sleep. Some strong noises lead to damage of the ear drum and makes the worker hearing impaired. Hence noise pollution should be reduced.

6. What is loudness? Give the relation between loudness and intensity of sound (or) State Weber-Fechner law.

Loudness of sound is defined as the degree of sensation produced on the ear. This cannot be measured directly. So that it is measured in terms of intensity. Loudness is proportional to logarithmic value of intensity.

$L \propto \log I$; $L = K \log I$; This is also known as Weber-Fechner's Law.

7. Define sound intensity level and write its unit.

Intensity level (I_L) is equal to the difference in loudness, which is given by

$I_L = L_1 - L_0 = K \log_{10} I_0$

where as L_1 is the loudness of any sound of intensity I_1 and L_0 is the loudness corresponding to the standard reference intensity I_0.

$$I_L = K log \frac{I_1}{I_0}$$

Unit for intensity level is Bel.

8. Mention how sound waves are classified.

Sound waves are classified into three categories on the basis of frequency.

1. Infrasonics (below 20 Hz)
2. Audible sound (between 20 Hz to 20.000 Hz)
3. Ultra sound (above 20,000 Hz)

Audible sound is further classified as

1. Musical sound which produces pleasing effect on the ear.
2. Noises which produces unpleasant effect on the ear.

9. We hear sound from a vibrating blade. If that sound is to be made louder, what should be done?

The sound from a vibrating blade can made louder by the following ways.

1. The size of the blade can be increased.
2. A resonant body should be kept near the vibrating blade.
3. By removing the sound absorbing material nearby the blade.

10. What is meant by quality of sound?

The quality of sound is that characteristic which enables us to distinguish between two notes of the same pitch and loudness produced by two different voices.

The loudness and pitch tell us whether it is a voice from a man or a woman. The quality will help us to recognize the particular person who is producing the sound without seeing him.

11. Give the relation between loudness and intensity.

S.No.	Loudness	Intensity
1.	It is the degree of sensation produced in the ear.	It is the energy of sound wave crossing per unit time through unit area at right angles to the direction of propagation.
2.	It is physiological quantity.	It is purely a physical quantity.
3.	It is difficult to measure.	It can be easily and accurately measured.

12. What are units of loudness? Define them.

There are two units of loudness viz., Decibel, Phon and sone.

Decibel: It is the smallest unit compared to Bel . It is the standard unit used to measure the loudness. One decibel is equal to one tenth of bel.

Phon : The measure of loudness in phon of any sound is equal to the loudness in decibels of an equally loud pure tone of frequency 1000Hz.

Sone : The measure of loudness in sone of any sound is equal to the loudness of that particular sound, having a loudness of 40 phons.

13. State Sabine's law.

It states that the reverberation time is the time taken by the sound to fall to one millionth of its original intensity, after the source of sound is stopped.

(i.e.) $I = \frac{I_0}{10^6}$

If V is the volume of the hall, a is the average absorption coefficient and S is the total surface area, the reverberation time can be related as

$$T = \frac{0.167V}{\sum aS}$$

14. What is meant by optimum reverberation time? Give its value for concert halls and theatres.

Optimum reverberation time is the persistent time of sound in Hall, without causing echo's (or) inaudibility.

(i) For concert halls it should be 0.5 seconds.

(ii) For small theatres it should be between 1.1 to 1.5 seconds and for large theatres it should be between 1.5 to 3 seconds.

15. Give the importance of Sabine's law for a good auditorium.

(i) The Sabine's law can be used to calculate the reverberation time of an auditorium.

(ii) It is also used to find the absorption coefficient of any unknown material.

(iii) The reverberation time should not be too short and also should not be too long. If the reverberation time is too short, the sound may not be sufficiently loud in all portions of the hall. If it is too long, echoes will be produced, so the reverberation time should be maintained with an optimum value for a good auditorium.

16. What is meant by echelon effect?

If there is a regular repetition of echoes of the original sound received by the observer due to the presence of flight of stairs or set of railings, then the effect is called echelon effect.

17. What is meant by resonance effect in acoustics?

Sometimes, due to lack of rigidity the window-panes or sections of the wooden portions may vibrate with some audio frequency. When this frequency is equal to the frequency of original sound. 'Resonance' will occur. This matching of frequency of any sound with the standard sound is called as resonance.

18. What is meant by structure borne noise?

Some buildings may have motors, elevators etc., which generates enormous sound intensity called noise. This noise travels through the structure of the buildings, called as structure borne noise.

19. State the conditions of good acoustics for an auditorium.

i. Sound should be sufficiently loud and intelligible in every part of the auditorium i.e., optimum reverberation time should be maintained.

ii. Sound of each syllable should decay soon so that the succeeding syllable may be heard distinctly. (i.e.) the auditorium must be free from excessive reverberation.

iii. There should not be any undesirable focusing of sound in any part of hall. There should not be any zone of silence or regions of poor audibility anywhere inside the hall.

iv. Resonance should be avoided and noise should be reduced.

v. Echoes should be avoided by covering the walls and ceilings with suitable absorbent materials.

20. A hall has a volume of 1200 m^3. Its total absorption is equivalent to 480 sq.m. of open

window. What will be the effect on the reverberation time if audience fills the hall and thereby increases the absorption by another 480 sq.m of open window?

Given data

Volume of hall (V) = $1200\ m^3$

Total absorption ($\sum$ as) = 480 OWU

Formula :

(i) Let T_1 be the reverberation time without audience, then we can write

Reverberation time $T_1 = \frac{0.167\ V}{\sum as}$

$T_1 = \frac{0.167x1200}{480}$

= 0.4175 seconds

(ii) Let T_2 be the reverberation time with audience, which increases the absorption by another 480 sq.m. of open window.

Reverberation time $T_2 = \frac{0.167x1200}{480+480}$

Reverberation time T_2 = 0.20875 seconds (or)

Change in Reverberation time

Due to audience is T = T_1- T_2

= 0.4175 - 0.20875

T = 0.20875 sec

Reverberation time reduces to 0.20875 sec. due to audience

21. The volume of a hall is 475m³. The area of wall is 200m², area of floor and ceiling each is 100m². If absorption coefficient of the wall, ceiling and floor are 0.025, 0.02 and 0.55 respectively, calculate the reverberation time for the hall.

Given data: V = $475m^3$, a_1 = 0.025 , a_2 = 0.02 ; a_3 = 0.55 , S_1 = 0.025 , S_2 = 0.02 S_3= 0.55

Formula Reverberation Time $T_1 = \frac{0.167\ V}{\sum as}$

$= \frac{0.167x475}{(200x0.025+100x0.02+100x0.55)}$

$= \frac{79.325}{62}$

Reverberation time of the hall = 1.279 sec

22. A hall has a volume of 1, 20,222 m³. It has a reverberation time of 1.5 seconds. What is the average absorbing power of the surface if the total absorbing surface area is 25,000 m².

Given data: Volume of hall (V) = $1,20,000\ m^3$, Reverberation time (T) = 1.5 seconds

Total absorbing surface area ($\sum$s) = $25,000\ m^2$

Formula: Reverberation Time

$$T = \frac{0.167\ V}{\sum as}$$

Total absorption coefficient $\sum as = \frac{0.167\ V}{T}$

$$\sum as = \frac{0.167X1,20,000}{1.5}$$

$\sum as$ = 13.360 OWU

Average absorbing power of the surface $a = \frac{0.167}{\sum ST}$

$a = \frac{13,360}{25,000}$

= 0.5344 Sabine

Average absorbing power of the surface = 0.5344 Sabine

23. A cinema theatre has a volume of 7500m³. What should be the total absorption in the theatre if the reverberation time of 1.5 seconds is to be maintained?

Given data T = 1.5 sec; V=7500m

Formula: Reverberation Time $T = \frac{0.167\ V}{\sum as}$

Total absorption $\sum as = \frac{0.167\ V}{T}$

$= \frac{0.167X7500}{1.5}$

= 835 OWU

Total absorption in the theatre = 835 open window units.

24. A loud speaker emits energy equally in all directions at the rate of 1.5 joules per second. What is the intensity level at a distance of 20 meters?

Standard Intensity level = 10^{-12} watt per m^2

Given data

Distance = Radius of the area = 20 m

Power = 1.5 Joules/sec

I_o = $1x10^{-2}$ W/m^2

Formula: Power = Intensity x Area

Since the sound spreads spherically outwards, we can write

$$P = I \times 4\pi^2$$

$$1.5 = I \times 4\pi \times 20^2$$

$$I = \frac{1.5}{4\times3.14\times20^2} = 2.98567\times10^{-4} W/m^2$$

Sound intensity level at a distance of 20 metres.

$$I_L = 10 \log 10 \frac{I}{I_0} \text{ dB}$$

$$I_L = 10 \log 10 \frac{2.98567\times10^{-4}}{1\times10^{-12}}$$

I_L= 10 x 8.475 = 84.75dB

Intensity level at 20m = 84.75 dB

25. A hall has be volume of 12500 m^3 and reverberation time of 1.5 sec. If 200 cushioned chairs are additionally placed in the hall, what will be the new reverberation time of the hall? The absorption of each chairs 1 O.W.U.

Given Data: V=12550 m^3 ; T= 1.5sec ; a_1s_1= 200

Formula:

Reverberation Time $T_1 = \frac{0.167\ V}{\sum as}$

(i) Before adding the cushioned chairs

Reverberation Time $T_1 = \frac{0.167\ V}{\sum as}$

(or) $\Sigma as = \frac{0.167\times12500}{1.5} = 1391.66$ O.W.U

After adding cushioned chairs

$$T_2 = \frac{0.167}{\Sigma as + a1s1}$$

$T_2 = \frac{0.167\times12500}{1391.66+200}$ =1.311 sec

The new reverberation time after adding the cushioned chairs =1.311 sec.

26. The volume of an auditorium is 12000m^3. Its reverberation time is 1.5 second. If the average absorption coefficient of interior surfaces is 0.4 Sabine /m^2, find the area of interior surfaces.

V= 12000m^3, T = 1.5 seconds, $\bar{a}$ = 0.4 Sabine /m^2

Formula: Reverberation Time $T = \frac{0.167\ V}{\sum aS}$

Total surface area $S = \frac{0.167\times12000}{0.4\times1.5}$ = 3340 m^2

Total surface area S= 3340 m^2

27. The volume of a room is 1500m^3. The wall area of the room is 260m^2, the floor area is 140m^2 and the ceiling area is 140m^2. The sound absorption coefficient for wall is 0.03, for the

ceiling is 0.8 and for the floor is 0.06. Calculate the average absorption coefficient and the reverberation time.

$V = 1500m^3$, $S_1 = 260m^2$ $S_2 = 140m^2$ $S_3 = 140m^2$

$a_1 = 0.03$, $a_2 = 0.8$, $a_3 = 0.06$

Formula : (i) Reverberation time $T = \frac{0.167\ V}{\sum aS}$

$$= \frac{0.167 \times 1500}{(0.03 \times 260)+(0.8\times 140)+(0.06 \times 140)}$$

$$= \frac{250.5}{128.2} = 1.9539 \text{ sec.}$$

Reverberation time 'T' = 1.9539 sec

Formula: (ii) Average absorption co-efficient $a = \frac{0.167}{\Sigma ST}$

$$= \frac{0.167}{(260+140+140)\times 1.9539}$$

a = 0.2374 Sabines

28. A window whose area is 1.4m² opens on a street where the street noise results in an intensity level at the window of 60 decibels. How much acoustics power enters via the window? (standard intensity level = 10^{-12} watt per m²)

Given data: Area of the window = 1.4 m²

Intensity level at the window = 60 decibels

Standard intensity level = 1×10^{-12} watt/m²

Formula Intensity level $I_L = 10 \log 10 \frac{I}{I_0}$

$$60 = 10\ log \frac{I_1}{10^{-12}} \text{ dB}$$

Therefore intensity $(I_1) = 1\times10^{-6}$ W/m²

Power = Intensity x Area

$= 1\times10^{-6}\times1.4$

$= 1.4\times 10^{-6}$ Watts

Acoustic power that enters via the window = 1.4×10^{-6} watts

29. Calculate the intensity level of a turbine whose sound intensity is 100 Wm^{-2} when it is under operation. Given that the standard intensity level is 10^{-12} Wm^{-2}.

Given data Intensity of sound (I_1) = 100W/m²

Formula: $I_L = 10 \log 10 \frac{I}{I_0}$

Therefore $I_L = 10 \log 10 \frac{100}{10^{-12}}$

(or) $I_L = 10\log_{10} 10^{14}$

Therefore I_L = 10 x 14 = 140 dB

Intensity level of a turbine = 140 dB

30. A hall of volume 1000m³ has a sound absorbing surface of area 400m². If the average absorption coefficient of the hall is 0.2,what is the reverberation time of the hall?

Given data: V =1000m³ s = 400m² Average absorption Coefficient (a) = 0.2

Formula: Reverberation time $T = \frac{0.167\ V}{\sum aS}$

$$= \frac{0.167 \times 1000}{0.2 \times 400} = 2.0875 \text{ seconds}$$

Reverberation time of the hall = 2.0875 seconds

31. The average reverberation time of a hall is 1.5 seconds and the area of the interior surface is 3340 m². If the volume of the hall is 12000m³, find the absorption coefficient.

Given data: Reverberation time T = 1.5 seconds

Surface area S = 3340m²

Volume of the hall V = 12000m²

Formula: We know Reverberation time $T = \frac{0.167\ V}{\sum aS}$

Therefore Absorption coefficient $a = \frac{0.167}{\Sigma ST}$

$= \frac{0.167 \times 12000}{3340 \times 1.5}$ = 0.4 Sabines

The average absorption coefficient of the hall (a) =0.4 Sabines.

32. What is the difference between Piezo electric method and Magnetostriction method?

S.No	Piezo Electric Method	Magnetostriction Method
1	It generates very high frequencies (500MHz)	It generates low frequency ultrasonic waves (3MHz).
2	The peak of resonance curve is narrow	The peak of resonance curve is broad.
3	Frequency of oscillation is independent of temperature.	Frequency of oscillation depends on temperature.

33. Why are not ultrasonics produced by passing high frequency alternating current through a loud speaker?

i. Loud speaker coil cannot vibrate at such high frequency.
ii. Inductance of the speaker coil becomes so high and practically no current flows through it.

34. What are the applications of SONAR?

i. SONAR is useful in all merchant and military ships.
ii. It is used in finding the distance and detecting of submarines.
iii. It is used for seismic(earthquake) survey.
iv. It is used to locate shoal of fish.

35. What are the advantages of ultrasonics in medical field over other techniques?

i. There is no ionization
ii. It doesn't affect the fetus of the mother during diagnosis.
iii.There is no mutation(or) residual effects.

36. Mention some of the chemical application of ultrasonics .

i They are used to increase the sensitivity of colour in photographs by dispersion of dye in the emulsion.
ii. They are used to remove air bubbles in the liquid metals and convert them in to fused metals.

37. Mention the properties of ultrasonics.

i. They are highly energetic.
ii. They are nothing but acoustical waves.
iii. They show negligible diffraction due to their small wavelength.

38. Are ultrasonic waves electromagnetic ? Give reasons .

Ultrasonic waves are the mechanical waves. They need medium for propagation and also they are longitudinal in nature. Hence they are not electromagnetic.

39. Explain Doppler effect?

There is an apparent change in frequency of the sound waves emitted from the source, when there is a relative motion between the source and observer. This effect is called Doppler effect and shift in frequency is called as Doppler shift

40. What are the methods used to produce ultrasonic?

i. Mechanical generator
ii. Magnetostriction oscillator method
iii. Piezo –electric oscillator method.

41. What are ultrasonic waves?

The sound waves having frequencies above the audible range (i.e.) above 20,000 Hz are known as ultrasonic waves. Generally, they are called high frequency waves.
Such waves cannot be heard by human ear. Ultrasonic waves have found wide applications in science, engineering, industry and medicine.

42. Mention the properties of ultrasonic waves.

i. They have high energy content.
ii. Just like ordinary sound waves, ultrasonic waves get reflected, refracted and absorbed.

ii. They can be transmitted over a long distances with no appreciable loss of energy.

iv. They produce intense heating effect when passed through a substance.

43. Explain the term SONAR

Sound Navigation and Ranging is termed as sonar. It is one of the application of ultrasonic waves.

44. What is magnetostriction effect?

When a rod of ferromagnetic materials like iron, nickel, cobalt or alloys of these is subjected to magnetic field parallel to its length, it undergoes a change in length. This is known as magneto-striction effect

45. What is the basic principle behind the magnetostriction oscillator to generate ultrasonic waves?

If a ferromagnetic material in the form of a rod (like iron or nickel) is subjected to alternating magnetic field, the rod expands and contracts in length alternately.

46. What is piezo-electric effect?

When pressure is applied to one pair of opposite faces of crystals like quartz cut with their faces perpendicular to the optic axis then equal and opposite electrical charges develop on the other pair of opposite faces. This is known as piezo-electric effect.

47. What is inverse piezo-electric effect or electrostriction?

If alternating voltages (potential difference) are applied to one pair of faces, then alternative mechanical expansion or contraction is developed across the other pair of opposite faces. This is known as inverse piezo-electric effect.

48. How is ultrasonic waves used in detection of flaws in metals.

It is based on the principle of reflection of ultrasonic waves at the interfaces.

49. What are the advantages of ultrasonic testing in metals?

The advantages are

i. the flaws present inside the metal can also be detected

ii. the detected metal can be used further for various purposes

iii. Capability of estimating the size, orientation, shape and nature of defects.

iv. High sensitivity, permitting the detection of extremely small flaws.

50. What is acoustic grating?

When ultrasonic waves are generated in a liquid kept in rectangular vessel, the wave can be reflected from the walls of the vessel. The direct and reflected waves get superimposed, which causes a standing wave to be formed. The density of the liquid at the node will be more than the density at an antinode. Under these conditions, if a beam of light is passed through the liquid at right angles to the wave the liquid acts as a diffraction grating. Such a grating is known as an acoustical grating.

51. Given that the velocity of ultrasonic waves in sea water is equal to 1440 m/s. Find the depth of a submerged submarine if an ultrasonic pulse reflected from the submarine is received 0.33 sec after sending the ultrasonic waves.

Total distance travelled by ultrasonics,

$$= v \times t = 1440 \times 0.33 = 475.20\text{m}$$

Total distance travelled by ultrasonics waves in going from source to submarine and back after reflection is equal to twice the depth of submarine.

Therefore depth of submerged submarine is half of the total distance travelled by ultrasonics = 475.2/2 = 237.5 m

PART - B

1. (i) What is the phenomenon of magnetostriction? How will you produce, with its help, high frequency sound waves?

   (ii) A quartz crystal of thickness 1 mm is vibrating at resonance. Calculate the fundamental frequency. Given Y for quartz = 7.9×10^{10} Nm^{-2} and ρ for quartz = 2650 kgm^{-3}.

2. (i) Explain piezo-electric effect. Describe the piezo-electric method of producing ultrasonic waves.

   (ii) Calculate the frequency of the fundamental note and the first overtone emitted by the piezo-electric crystal. Using the following data, vibrating length is 4 mm, Young's modulus of quartz = 7.9×10^{10} N/m^2 and density of crystals 2650 kgm^{-3}.

3. (i) Explain in detail how the ultrasonic pulse technique is used for non-destructive testing for materials.

(ii)Write short note on SONAR.

4. (i) Explain how ultrasonic waves are used to find the depth of the sea.
   (ii) Given that the velocity of ultrasonic waves in sea water is equal to 1440 m/s. Find the depth of a submerged submarine if an ultrasonic pulses reflected from the submarine is received 0.45 sec after sending the ultrasonic waves.
5. (i) What is acoustic grating? How it is used to find the velocity of ultrasonic waves in liquid medium?
   (ii) An ultrasonic interferometer used to measure the velocity in sea water. If the distance between two consecutive antinode is 0.55 mm. Compute the velocity of the waves in sea water. The frequency of the crystal is 1.5 MHz.
6. (i) Describe a method to produce ultrasonic waves.
   (ii) Explain the applications of ultrasonic waves in engineering field?
7. (i) Explain the applications of ultrasonic waves in chemical and medical field?
   (ii) What is sonogram? How do you monitor the fetal heart rate using ultrasonic waves?
8. (i) Explain A – scan display?
   (ii) Draw the block diagram of pulse echo system & explain.
   (iii) Name the applications of ultrasound in medicine.

UNIT – IV QUANTUM PHYSICS

PART - A

1. Write any two drawbacks of classical free electron theory.

i. The electrical conductivity of semiconductors and insulators cannot be explained by this theory.
ii. The photo electric effect, Compton effect and black body radiation cannot be explained on the basis of this theory.

2. What is meant by a perfect black body?

A perfect black body is one which absorbs and also emits radiations of all wavelengths.

3. What is meant by energy spectrum of a black body?

The distribution of energy for various wavelengths at various temperatures is known as energy spectrum of a black body.

4. State Stefan-Boltzmann law.

It states that the radiant energy (E) of the body is directly proportional to the fourth power of the temperature (T) of the body.

$$E \alpha T^4 ; E = \sigma T^4$$

5. State Planck's hypothesis.

The atomic oscillators can absorb or emit energy in the multiples of small unit called quantum. The quantum of radiation is called photon. The energy of the photon (ε) is proportional to the frequency of radiation (ν).

6. What is meant by Photon? Give any two properties.

i. Photons are discrete energy values in the form of small quanta of definite frequency (or) wavelength.
ii. They do not have any charge and they will not ionize gases.
iii. The energy and momentum of the photon is given by $E = h\nu$ and $p = mc$

7. State Planck's law of radiation.

The energy density of radiation in an enclosure at temperature T in the wavelength range λ and $\lambda + d\lambda$ is

$$E_\lambda = \frac{8\pi hc}{\lambda^5} \times \frac{1}{e^{\left(\frac{hc}{\lambda kT}\right)} - 1}$$

8. Define Wien's displacement law.

It states that the product of the wavelength (λ_m) of maximum energy emitted and the absolute temperature (T) is a constant.

$$\lambda_m T = \text{constant}$$

9. Define Rayleigh – Jeans law.

It states that the energy is directly proportional to the absolute temperature and is inversely proportional to the fourth power of the wavelength.

$$E_\lambda \propto T / \lambda^4$$

10. Arrive at Wien's displacement law from Planck's law.

$$E_\lambda = \frac{8\pi hc}{\lambda^5} \times \frac{1}{e^{\left(\frac{hc}{\lambda kT}\right)} - 1} ; \qquad e^{\left(\frac{hc}{\lambda kT}\right)} - 1 = e^{\left(\frac{hc}{\lambda kT}\right)}$$

$$E_\lambda = \frac{8\pi hc}{\lambda^5 e^{\left(\frac{hc}{\lambda kT}\right)}}$$

11. Arrive Rayleigh Jeans law from Planck's law.

$$E_\lambda = \frac{8\pi hc}{\lambda^5} \times \frac{1}{e^{\left(\frac{hc}{\lambda kT}\right)} - 1}$$

$$e^{\left(\frac{hc}{\lambda kT}\right)} = 1 + \frac{hc}{\lambda kT} \qquad E_\lambda = \frac{8\pi hc}{\lambda^4}$$

12. Write any two postulates of Planck's quantum theory?

i. The electrons in the black body are assumed as simple harmonic oscillators.
ii. The oscillators will not emit energy continuously.

13. Define Compton Effect and Compton shift.

When a photon of energy h ν collides with a scattering element , the scattered beam has two components, one of the same wavelength as that of the incident radiation and the other has higher wavelength compared to incident wavelength. This effect is called Compton effect. The shift in wavelength is called Compton shift.

14. Explain the variations of Compton shift with respect to the scattering angle.

The Compton shift in wavelength increases with the increase in scattering angle as shown below. We know that Compton shift, $d\lambda = \frac{h}{m_0 c}(1 - \cos\theta)$

Case i) when $\theta = 0$, $d\lambda = 0$
Case ii) when $\theta = 45°$, $d\lambda = 0.0071$Å
Case iii) when $\theta = 90°$, $d\lambda = 0.02424$Å
Case iv) when $\theta = 180°$, $d\lambda = 0.0472$Å

15. What are matter waves?

The waves associated with the particles of matter (electrons, photons) are known as matter waves.

16. State de – Broglie's hypothesis.

Light exhibits dual nature (i.e.,) it can behave both as a particle and wave, de-Broglie suggested that an electron, which is particle can also behave as a wave and exhibits the dual nature.

17. How de-Broglie justified his concept?

i. Our universe is fully composed of light and matter
ii. Nature loves symmetry. If radiation like light can act like wave as well as particle, then material particles should also act as particle as well as wave.
iii. Every moving particle is associated with a wave

18. State the properties of the matter waves.

i. Lighter the particle, greater is the wavelength associated with it
ii. Smaller the velocity of the particle, greater is wavelength associated with it

iii. These waves are not electromagnetic waves but they are a new kind of waves

19. Write an expression for the wavelength of matter waves? (or) What is de-Broglie's wave equation?

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

where; h – Planck's constant, m – mass of the particle, v – velocity of particle, p – momentum of the particle.

20. What do you understand by the term wave function?

Wave function ψ is a variable quantity that is associated with a moving particle at any position (x,y,z) and at any time 't'. It relates the probability of finding the particle at that point and at that time.

21. What is the physical significance of a wave equation?

i. The probability of finding a particle in space at any given instant of time is characterized by a function ψ (x, y, z) called wave function.

ii. It relates particle and wave statistically

22. Write any two applications of Schrodinger wave equation.

i. It is used to find the electrons in the metal.

ii. It is used to find the energy levels of an electron in an infinite deep potential well.

23. Write down the one dimensional Schrödinger time independent equation and write the same for a free particle.

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}[E - V]\psi = 0$$

For a free particle, V = 0. So, $\frac{d^2\psi}{dx^2} + \frac{2mE}{\hbar^2}\psi = 0$

24. Define Eigen value and Eigen function.

Eigen value is defined as energy of the particle and is denoted by the letter (E_n). Eigen function is defined as the wave function of the particle and is denoted by the letter (ψ_n)

$$E_n = \frac{n^2h^2}{8ma^2} \qquad \psi_n = \sqrt{\frac{2}{a}}\sin\frac{n\pi x}{a}$$

25. Define normalization process.

Normalization is the process by which the probability of finding a particle inside any potential well can be done.

26. What are the merits of quantum free electron theory?

i. Specific heat of solids at low temperature can be explained

ii. Theory of atomic structure and spectrum of hydrogen can be explained

27. What is electron microscope?

It is a microscope in which the object is illuminated by highly accelerated fast-moving electron beam. It has very high magnification of about 100,000 X, and very high resolving power.

28. What is the basic principle of electron microscope?

The given object is illuminated by highly accelerated fast-moving electrons. The focusing of the beam is done by magnetic fields (magnetic lenses). The shorter wavelength of electron permits the detailed examination of tiny objects due to reduction of diffraction effects.

29. What are the types of electron microscope?

i. Transmission electron microscope (TEM)

ii. Scanning electron microscope (SEM)

iii. Scanning Transmission electron microscope (STEM)

30. Write the principle of TEM.

The electrons are accelerated up to high energy levels and focused on a specimen. The electron beam transmitted through the specimen is collected and analyzed.

31. Write the principle of SEM.

When the accelerated primary electron strikes the sample, it produces secondary electrons. These secondary electrons are collected by a detector which in turn gives a three dimensional image of the sample.

32. Write the difference between optical and electron microscopes.

Optical microscope	Electron microscope
Lenses used are made of glass	Lenses are formed by electrostatic or magnetic fields
Large aperture	Small aperture
Magnifying power is low ~ 2000 X	Magnifying power is high ~ 100,000 X

33. What is G.P. Thomson experiment?

G.P. Thomson made investigations with high speed electrons, accelerated by a potential difference ranging from 10,000 to 50,000 volts and studied the electron diffraction effects. Thomson found the diffraction patterns exactly analogous to X-ray patterns. Moreover, he was able to determine the wavelengths associated with electrons.

34. Find the energy of an electron moving in one dimension in an infinitely high potential box of width 0.1 nm.

$$E_n = \frac{n^2 h^2}{8ma^2}$$

$$= \frac{1^2 \times (6.625 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (0.1 \times 10^{-9})^2} = 6.022 \times 10^{-18}\, J$$

35. Calculate the number of photons emitted by a 100 watts sodium vapor lamp. Given λ = 5893 Å.

$$E = \frac{hc}{\lambda}$$

$$= \frac{6.625 \times 10^{-34} \times 3 \times 10^{8}}{5893 \times 10^{-10}}$$

$= 3.3726 \times 10^{-19}$ J

N = Power / Energy

$$= \frac{100}{3.3726 \times 10^{-19}}$$

$= 2.2965 \times 10^{20}$ per second

36. Calculate the de-Broglie wavelength of an electron accelerated to a potential of 2 kV.

$$\lambda = \frac{h}{\sqrt{2mev}}$$

$$= \frac{6.625 \times 10^{-34}}{\sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}} = 0.2774 \text{ Å}$$

37. X-rays of wavelength 0.124 Å are scattered by a carbon block. Find the wavelength of scattered for a scattering angle of 180 º.

$$\lambda' = \lambda + \frac{h}{m_0 c}(1 - \cos\theta)$$

$$\lambda' = \left(0.124 \times 10^{-10}\right) + \frac{6.625 \times 10^{-34}}{9.11 \times 10^{-34} \times 3 \times 10^{8}}\left(1 - \cos 180^\circ\right) = 0.1725 \text{ Å}$$

38. In a Compton scattering experiment, the incident photons have a wavelength of $3x\ 10^{-10}$ m. Calculate the wavelength of scattered photons if they are viewed at an angle of 60^0 to the direction of incidence.

$$\lambda' = \lambda + \frac{h}{m_0 c}(1 - \cos\theta)$$

$$\lambda' = \left(3 \times 10^{-10}\right) + \frac{6.625 \times 10^{-34}}{9.11 \times 10^{-34} \times 3 \times 10^{8}}\left(1 - \cos 60^\circ\right) = 3.0121 \text{ Å}$$

PART - B

1. Using Quantum theory, derive an expression for the average energy emitted by the black body

and arrive at Planck's radiation law.

2. With the concepts of quantum theory of black body radiation derive an expression for energy distribution and use it to prove Wien's displacement law and Rayleigh Jeans law.
3. Define Compton Effect and explain its significance? Derive an expression for the change in wavelength due to Compton scattering by incident light with matter.
4. Write down the equation for Compton shift and discuss it for various angles of scattering with an experimental evidence to prove it.
5. Derive time independent Schrödinger wave equation and hence deduce time dependent Schrödinger wave equation. Give the physical significance of wave function
6. Derive time independent Schrödinger equation for one dimensional case. Also prove that for a particle enclosed in a one dimensional box.
7. With quantum concepts, explain the energy level of an electron enclosed in an infinity deep one dimensional potential box.
8. Using Schrodinger's time independent wave equation normalize the wave functions of electron trapped in a one dimensional potential well.
9. Describe the construction and working of a Scanning electron Microscope with a neat diagram.
10. Draw a neat diagram and explain the working of Transmission electron Microscope.
11. Explain G. P. Thomson experiment.

UNIT – V LASER

PART - A

1. What is the principle of laser action?

Stimulated emission process is a key factor for the laser action. The multiplication of photons through stimulated emission leads to coherent, powerful, monochromatic, collimated beam of laser.

2. What is stimulated emission?

The process of induced emissions of photons caused by the incident photons is called stimulated emission.

3. What are the conditions required for stimulated emission of radiation?

i. More number of atoms must be in excited state
ii. The external radiation must strike the atoms in the excited state.

4. What are the difference between spontaneous emission and stimulated emission?

Spontaneous emission	Stimulated emission
Emission of light is caused without any external influence	Induced emissions of light caused by incident photons
Emitted photon travels in random direction	Emitted photons can be made to travel in particular direction
Emitted photons cannot be controlled	Emitted photons can be controlled

5. What are the characteristics (properties) of the laser?

i. Laser light is highly coherent.
ii. It is highly intense.
iii. It is highly directional.
iv. It is highly monochromatic.

6. What are coherent source?

Coherent sources are the sources which have same wavelength and frequency. It has correlation with the amplitude and phase at any point with any other point.

7. Define coherent length and coherent time? How are they related to each other?

The maximum length up to which waves trains have correlation with the amplitude and phase is called coherent length and the time up to which they are correlated is called coherent time. They are related as, coherent time = Coherent length / velocity of light

8. What is meant by LIDAR?

Light detection and ranging – Laser beams are used to determine the exact size, form, distance, velocity and direction of distant objects by receiving the reflected laser beam as in RADAR.

9. What is meant by population inversion?

The number of atoms in the excited state (higher energy level) is more than that of ground state (lower energy level) is known as population inversion.

10. Explain the need for population inversion in the production of laser?

Stimulated emission is a key factor for the production of laser. For stimulated emission, more number of atoms must be in the excited state which is only achieved by population inversion.

11. What is pumping action?

The process of creating population inversion in the atomic states is known as pumping action. It is essential requirement for producing a laser beam.

12. What are different methods of pumping?

i. Optical pumping.
ii. Electron discharge method
iii. Inelastic atom-atom collision
iv. Direct conversion
v. Chemical process.

13. What is optical pumping?

When the atoms are exposed to light radiations, atoms in the lower state absorb their radiations and go to excited state. This method is called optical pumping.

14. What is meant by optical resonator?

An optical resonator or a resonance cavity is a feedback system, which consists of an active medium kept in between a 100% mirror and a partial mirror. Here the intensity of light produced in the active medium is increased by making the light to bounce back and forth between the mirrors. Finally the laser beam comes through the partial mirror.

15. What are the conditions required for laser action?

i. Population inversion should be achieved
ii. Stimulated emission should dominate over spontaneous emission

16. Define active medium.

The medium in which the population inversion can be achieved is called active medium.

17. What are the three important components of any laser device?

i. Active medium ii .Pumping device iii.Optical resonator

18. Classify different types of lasers based on active medium.

i. Solid state laser – Ruby, Nd-YAG
ii. Gas laser – CO_2 , He –Ne
iii. Liquid laser – Europium chelate
iv. Dye laser – Coumarin dye laser
v. Semiconductor laser – GaAs

19. What is Nd:YAG laser?

Nd:YAG is neodymium based laser. It is a four level solid state laser.

20. What are the applications of Nd:YAG laser?

i. Range finders and illuminators
ii. Micro machining operations as well as welding and drilling
iii. Medical applications like endoscopy, urology, ENT etc.

21. What is CO_2 laser?

It is a four level molecular gas laser. The active medium of this laser is CO_2 gas. Laser transition takes place between the vibrational states of CO_2 molecules.

22. What is the use of nitrogen and Helium in CO_2 laser?

In CO_2 laser , nitrogen helps to increase the population of atoms in the upper level CO_2 . While helium helps to depopulate the atoms in the lower level of CO_2 and also to cool the discharge tube.

23. Give the wavelengths of light emitted by the CO_2 laser.

The wavelength of light emitted by the CO_2 laser is 9.6μm and 10.6 μm.

24. What are the applications of CO_2 laser?

i. Materials processing, welding, drilling, cutting etc.
ii. Laser remote sensing
iii. Neurosurgery and bloodless operations.

25. What is semiconductor laser?

Semiconductor laser is a specially fabricated p-n junction device. It emits light when it is forward biased.

26. What is homo-junction laser?

Homo-junction laser means that a p-n junction is formed by a single crystalline material.
Example: Gallium Arsenide (GaAs)

27. What is hetero-junction laser?

Hetero-junction laser means that a p-n junction has two different materials. Example: Hetero-junction laser can be formed between GaAs and GaAlAs.

28. What are differences between homojunction and heterojunction laser?

Homojunction laser	Heterojunction laser
Made by single crystalline material.	Made by different crystalline materials.
Power output is low.	Power output is high
Pulsed output.	Continuous output.
Life time is less.	Life time is more.
Ex: GaAs , InP	Ex: Inp/ InAlPS

29. What are the drawbacks of homojunction laser diodes?

i. Threshold current is very large
ii. The output beam has large divergence
iii. Coherence and stability are poor.

30. What are the advantages of heterojunction lasers?

i. Threshold current is very low
ii. Continuous wave operation is possible
iii. Very narrow beam with high coherence and monochromacity is achieved

31. What are the applications of semiconductor laser?

i. It is mostly used in fiber optical communications
ii. It is used to heal the wounds by means of infrared radiation
iii. It is used in printers for computer laser printers, writing and reading CD's

32. Why the shape of LED made hemispherical?

In planer LED's the emitted light strikes the material interface at an angle greater than the critical angle and the reflection loss will be very high. Therefore to minimize the reflection loss, hemispherical dome shaped LED is made, in which the angle at which the emitted light strikes the interface can be made less than the critical angle.

33. What is laser material processing?

Material processing involves cutting, welding, drilling and surface treatment. When the material is exposed to laser light, then light energy is converted into heat energy. Due to heating effect, the material is heated then melted and vaporized.

34. Mention the applications of lasers in industry.

i. Welding ii. Cutting iii. Drilling iv. Non-destructive testing

35. What is laser welding?

In this technique, a focused laser beam is incident on the spot where the two parts are to be welded. The spot-contact points get welded.

36. What are the advantages of laser welding?

i. Laser welding is contactless; therefore there is no possibility of introduction of harmful impurities
ii. It can be performed in atmospheric pressure unlike electron beam welding where vacuum is a must

37. What is heat treatment of laser?

A powerful laser is allowed to hit a metal surface. That portion gets heated. As the beam is moved away to other areas, the heated spots cool down rapidly. This procedure is used for heat treatment of metal surfaces which enhances the strength of the metal.

38. Mention the medical applications of laser.

i. Treatment of detached retinas
ii. Micro-surgery and bloodless operation
iii. Treatment of human and animal cancer and skin tumors

39. In InP Laser diode, the wavelength of light emission is 1.55 µm. What is its band gap in eV? (May '03)

$$E_g = \frac{hc}{\lambda} = 0.8014\, eV$$

40. Calculate the number of photons from green light of mercury λ = 4961Å requires to do one joule of work

$$E_g = \frac{hc}{\lambda} = 4.006 \times 10^{-19} J$$

$$N = \frac{1J}{4.006\times10^{-19} J} = 2.4961 \times 10^{18} \, / \, m^3$$

41. Calculate the long wavelength limit of extrinsic semiconductor if the ionization energy is 0.02 eV.

$$\lambda = \frac{hc}{E_g} = 6.210 \times 10^{-5} m$$

42. Calculate how many photons are emitted in each minute in a helium neon laser which emits light at a wavelength of 6328 Å . The out power of the source 3mW.

Frequency $\nu = \frac{c}{\lambda} = 4.74 \times 10^{14} Hz$

E = hυ = 3.14 x10 $^{-19}$ J

Energy emitted by the laser = 3mW = 3 x 10 $^{-3}$ x 60 J / minute

No of photons emitted = $N = \frac{3 \times 10^{-3} \times 60}{3.14 \times 10^{-19}} = 5.732 \times 10^{17} =$ photons / min

43.Explain the structure of optical fibre.

Optical fiber consists of an inner cylinder made of glass or plastic called core. The core is surrounded by a cylindrical shell of glass or plastic called cladding. The cladding is covered by a jacket that protects the fibre from moisture and abrasion. The refractive index of core is always greater than that of cladding.

44. Define 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 of the fiber.

45. Define numerical aperture of a fiber.

It is the light collecting efficiency of the fiber. It is a measure of the amount of light rays that can be accepted by the fiber. It is equal to the sine of the acceptance angle.

46. What are the conditions to be satisfied for the total internal reflection?

i. Light should travel from denser medium to rarer medium.
ii. The angle of incidence on core should be greater than the critical angle
iii. The refractive index of the core(n1) should be greater than the refractive index of the cladding (n2)

47. What are the types of optical fibers based on number of modes?

i. Single mode fiber – one mode ii. Multi mode fiber – many modes

48. What is single mode fiber?

If only one mode is transmitted through a fiber, then it is a single mode fiber.

49. What is multimode fiber?

If more than one mode is transmitted through a fiber, then it is a multi mode fiber.

50. What are the types of fibers based on refractive index profile?

i. Step-index fiber and ii. Graded-index fiber

51. Differentiate between single mode and multimode fiber.

Single mode fiber	Multimode fiber
In single mode fiber only one mode can be propagated.	Allows large number of modes of light to propagate through it.
Smaller core diameter and difference in refractive index of core and cladding is small.	Core diameter is large, the core and cladding refractive index difference is also large.
No dispersion of signal	Dispersion of signal takes place

52. Differentiate between step-index and graded-index fiber.

Step-index fiber	Graded-index fiber
Refractive index of the core is uniform throughout and undergoes an abrupt change at the cladding boundary	Refractive index of the core is made to vary gradually such that the maximum refractive index is present at the centre of the core
Attenuation is more for multimode step-index fiber	Attenuation is less
Numerical aperture is more multi mode step-index fiber	Numerical aperture is less

53. What are the losses that occur during optical fiber communication?

i. Attenuation ii. Distortion iii.Dispersion

54. Define attenuation in an optical fiber and mention its unit.

Attenuation loss is generally measured in terms of the decibel (dB). It is defined as the ratio of the optical power output from a fiber to the power input.

$$\alpha = -10\log\left(\frac{P_{out}}{P_{in}}\right)$$

55. What are basic attenuation mechanisms?

i. Absorption loss ii. Scattering loss iii. Radiative loss

56. What is absorption loss?

Absorption loss is related to fiber material. It is caused by three different mechanisms.

i. Absorption by atomic defects
ii. Extrinsic absorption by impurity atoms
iii. Intrinsic absorption by the basic constituent atoms of the fibre materials

57. Define dispersion.

Dispersion means degradation of the optical signal or signal distortion. In fiber optic communication system, the signal is launched in the form of light pulses with a given width, amplitude and spacing between pulses. During transmission, several effects lead to the spreading of pulse width. This effect is called dispersion.

58. What is the basic principle in optical fibre communication system?

The basic principle in optical fibre communication is transmission of information by propagation of optical signal through optical fibers over required distance. It involves deriving optical signal from electrical signal at transmitter end and conversion of optical signal back to electrical signal at the receiving end.

59. What are essential components of fiber optic communication system?

i. Light source
ii. Optical fiber transmission line
iii. Photo detector

60. Mention the advantages of fiber optic communication system over the conventional systems.

i. Light in weight and small in size.
ii. No possibility of internal noise and cross talk generation
iii. No hazards of short circuits as in metal wires

61 Why optical fibers are called as wave guides?

A wave guide is a tubular structure through which some sort of energy could be guided in the form of waves. Since light waves can be guided through a fiber, it is called wave guide.

62. Mention the applications of optical fibers in the engineering field.

i. It can be used for long distance communication in trunk lines.
ii. It is used in computer networks, especially in LAN.
iii. It is also used as optical sensors.
iv. It is used in defence services.

63. What is the basic principle of fiber sensors?

A fiber sensor consists of a light source. The light source is coupled to an optical fiber. A light detector receives signal-carrying light beam as it emerges from the fiber. The signal from detector is processed electrically for getting information.

64. What are essential components of optical fiber sensors?

i. Source
ii. Wave guide(fiber)
iii. Detector

65. How fibers are used as sensors?

The fiber optic sensors are used to detect changes in frequency, intensity, temperature, current, polarization of light waves etc. A fiber optic sensor modulates light passing through it, when it is exposed to change in environment.

66. What are the types of sensors used in the fibre optics?

i. Intrinsic sensors – Fibre itself acts as a sensing element
ii. Extrinsic sensors – Separate sensing system collects the light from the fibre

67. Calculate the numerical aperture and acceptance angle of an optical fibre having $n_1 = 1.49$ and $n_2 = 1.44$.

$$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.49^2 - 1.44^2} = 0.3827$$

68. A fiber has a diameter of 6μm and its core refractive index is 1.47 and for cladding it is 1.43. How many modes can propagate in to the fiber if the wavelength of the laser source is 1.5 μm. (Jan 2010)

$$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.47^2 - 1.43^2} = 0.34$$

$$N_{step} = 4.9\left(d \times \frac{NA}{\lambda}\right)^2 = 9.06 = 9 \text{ modes}$$

69. Calculate the numerical aperture and the acceptance angle of an optical fibre from the following data. Refractive index of core is 1.55, refractive index of cladding is 1.5.(Jan 2005)

(i) $NA = \sqrt{n_1^2 - n_2^2} = \sqrt{0.1525} = 0.3905$

(ii) $i_m = \sin^{-1}(NA) = \sin^{-1}(0.3905) = 22^0\, 59'$

70. A Step index fibre has a numerical aperture of 0.26, a core refractive index of 1.5 and a core diameter of 100 μm calculate,

a) The refractive index
b) The acceptance angle
c) The maximum number of modes with a wavelength of 1 μm that the fibre can carry.

$NA = \sqrt{n_1^2 - n_2^2} = 0.26 = \sqrt{1.5^2 - n_2^2}$

Refractive index of cladding, $n_2 = 1.4772$

Acceptance angle, $\sin i_m = NA/n_0 = 0.26/1 = 15^0\, 07'$

Maximum number of modes, $N = 4.9\left(d \times \frac{NA}{\lambda}\right)^2 = 3312.4$

71. A signal of 100 mW is injected into a fibre the out coming signal from the other end is 40 mW Find the loss in dB. (Jan 2010)

Power loss $\alpha = -10\log\left(\frac{P_{out}}{P_{in}}\right) = -3.979\, dB$

PART - B

1. Derive Einstein's relation for stimulated emission and hence explain the existence of stimulated emission.
2. What is pumping action? Explain the methods commonly used for pumping action.
3. Explain the construction and working of Nd YAG laser with a neat diagram.
4. Explain the principle, construction and working of a four level solid state laser.
5. Explain the modes of vibrations of CO_2 molecule. Describe the construction and working of CO_2 laser with necessary diagrams.
6. Describe the principle, construction, working and energy level diagram of semiconductor laser. What are the advantages of heterojunction laser over homojunction semiconductor laser?
7. With suitable diagram explain the construction and working of a homojunction Ga-As laser.
8. Describe the construction and working of a hetero-junction Ga-As laser.
9. Discuss the industrial applications of laser.
10. Discuss the medical applications of laser.
11. (i) Explain the propagation of light through optical fibre. (ii) What are numerical aperture and acceptance angle of a fiber? Explain two applications of optical fiber.
12. Derive an expression for Numerical aperture and Acceptance angle of a fibre in terms of refractive indices of the core and cladding.
13. Classify the optical fibres on the basis of materials, modes of propagation and refractive index difference. (or) Explain how fibers are classified.
14. Explain what is meant by step index and graded index fiber?
15. Describe the losses that occur in fibers and give the remedies for it.
16. What is dispersion in fiber optics? Explain different types of dispersion.
17. Explain with a neat block diagram, the working of fibre optical communication system.
18. Discuss how optical fibres are used in communication field. What are its advantages over the conventional methods.
19. What are the different types of fibre optic sensors? Explain the working of any two sensors.
20. Describe in detail anyone of the intrinsic and extrinsic sensors (or) Explain how fibres are used as sensing elements.
21. Describe the construction and working of a medical endoscope and give its applications in medical field.