EASWARI ENGINEERING COLLEGE

(Autonomous)

DEPARTMENT OF PHYSICS

QUESTION BANK

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UNIT I - MECHANICS

PART A QUESTIONS

1. Define multiparticle dynamics.

The study of dynamics of a system which consists of two or more particles is known multiparticle dynamics.

2. Define centre of mass of the system.

Consider the motion of a system consisting of a large number of particles. There is one point in it which behaves as though the entire mass of the system were concentrated there and all the external forces were acting at this point. This point is called the centre of mass of the system.

3. What is centre of mass (CM)?

A point in the system at which whole mass of the body is supposed to be concentrated is called centre of mass of the system.

4. Give the example for motion of centre of mass.

Examples for motion of centre of mass

(i) Motion of planets and its satellite

(ii) Projectile Trajectory

(iii) Decay of a Nucleus

5. How centre of mass is determined for rigid body and regular shape?

Centre of mass of some regular objects

- For a rigid body, the centre of mass is a point at a fixed position with respect to the body as a whole. Depending on the shape of the body and the way the mass is distributed in it, the centre of mass in a point may or may not be within the body.
- If the shape is symmetrical and the mass distribution is uniform, we can usually find the location of the centre of mass quite easily.
- For a long thin rod of uniform cross section and density, the centre of mass is at the geometrical centre.
- For a thin circular plane ring, it is again at the geometrical centre of the circle.
- For a rectangle, again the centre of mass is at the geometrical centre.

6. What is the difference between centre of gravity and centre of mass?

- The centre of gravity of a body is a point, where the whole weight of the body is supposed to be concentrated.
- The centre of mass of a body is that point, where the whole weight of the body is supposed to be concentrated.

For uniform geometrically shaped, bodies the centre of gravity coincides with centre of mass. However, they do not coincide in bodies whose density is not uniform throughout.

7. Define rigid body.

A rigid body is defined as that body which does not undergo any change in shape or volume when external forces are applied on it.

8. Define rigid body rotation.

When a body rotates about a fixed axis, its motion is known as rotatory motion. A rigid body is said to have pure rotational motion, if every particle of the body moves in a circle, the centre of which lies on a straight line is called the axis of rotation. (Fig. Rotational motion)

9. Write down the equation of motion for rotational motion.

$$\omega = \omega_0 + \alpha t \qquad ...(1)$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \qquad ...(2)$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \qquad ...(3)$$

10. Define moment of inertia of a body.

The property of a body by which it resists change in uniform rotational motion is called rotational inertia or moment of inertia.

11. Define moment of inertia of a particle.

The moment of inertia of a particle about an axis is defined as the product of the mass of the particle and square of the distance of the particle from the axis of rotation.

If 'm' is the mass of the particle and 'r' is the distance of the particle from the axis of rotation, then

The moment of inertia of the particle

$$I = Mr^2$$

12. Define moment of inertia of a rigid body.

The moment of inertia of a rigid body a given axis is the sum of products of masses of its particles and the square of their respective distances from the axis of rotation.

13. What are the factors the moment of inertia depends on?

Moment of inertia depends on mass, distribution of mass and on the position of axis of rotation.

14. What are the physical significance of moment of inertia?

The property which opposes the change in rotational motion of the body is called the moment of inertia. Greater is moment of inertia of the body about the axis of rotation, greater is the torque required to rotate the body.

Thus, it is clear that the moment of inertia of a body has the same role in rotational motion as that of mass (or inertia) in linear motion.

15. What is radius of gyration?

The radius of gyration is defined as the distance from the axis of rotation to the point where the entire mass of the body is assumed to be concentrated. K is called the Radius of Gyration of the body about axis of rotation. It is equal to the root mean square distance of all particles from the axis of rotation of the body.

16. What are the theorems on moment of inertia?

There are two important theorems which help to find the moment of inertia of a body about some other axis if moment of inertia about any symmetrical axis of the body is given. These

are called theorem of parallel and perpendicular axes.
They are
1. Parallel axes theorem and
2, Perpendicular axes theorem.

17. State parallel axis theorem.
The moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis passing through its centre of gravity of the body and the product of its mass of the body with the square of the distance between two axes.

18. State perpendicular axis theorem.
It states that the moment of inertia of a plane lamina about an axis perpendicular to its plane is equal to the sum of the moments of inertia of the plane lamina about any two mutually perpendicular axes in its own plane and intersecting each other at the point where the perpendicular axes pass through it.

19. Define angular momentum.
Angular momentum of a particle is defined as its moment of linear momentum. It is given by the product of linear momentum and perpendicular distance of its line of action from the axis of rotation. It is denoted by $\vec{L}$.

20. Define torque.
The moment of the applied force is called torque. It is represented by the symbol "τ".
If F is the force acting on a body at a distance r then,
Torque = Force x distance
I.e.,$\vec{\tau} = \vec{F} \times \vec{r}$
The rotational motion is due to only when the torque acts on the body.

21. State conversation of angular momentum.
The law of conservation of angular momentum states that in the absence of an external torque, the angular momentum of a body or a system of bodies remains conserved.

22. What is gyroscope?
A gyroscope is a device used for measuring or maintaining orientation and angular velocity. It is a spinning wheel or disc in which the axis of rotation (spin axis) is free to assume any orientation by itself.

23. What are the uses of gyroscope?
1. In view of the property of stability, the gyroscope is used as stabilizers in ships, boats and aeroplanes.
2. Due to the inherent stability of the gyroscope, it is used as a compass, and a gyro-compass is preferable to the magnetic compass in many respects.
3. Another important application of the directional stability of a rapidly spinning (rotating) body is the rifling of the barrels of the rifles.

24. What is torsional pendulum?
A circular metallic disc suspended using a thin wire that executes torsional oscillation is called torsional pendulum.

25. What are the uses of torsional pendulum?
Torsional pendulum is used to determine
1. Rigidity modulus of the wire
2. Moment of inertia of the disc

3. Moment of inertia of an irregular body.

PART B QUESTIONS

1. Discuss the Centre of mass and obtain the expression for the same for a system of particles. Also, outline the motion of Centre of mass.

2. Derive an expression for the moment of inertia of a uniform rod
   a) About an axis through its centre and perpendicular to its length
   b) About an axis passing through one end of the rod and perpendicular to its length.
3. Derive an expression for the moment of inertia of a thin circular disc.
   a) About an axis through its centre and perpendicular to its plane.
   b) About a diameter.
4. Derive an expression for the moment of inertia of a diatomic molecule.

5. Derive an expression for the moment of inertia of a solid cylinder.
   a) About an axis through its centre and perpendicular to its length
   b) About the axis of cylinder.
6. Describe the principle, construction and working of gyroscope and also mention its applications in various field.
7. Derive an expression for time period of torsion pendulum. Explain how it is used to find rigidity modulus of a wire.
8. Derive an expression for centre of mass of a solid cone.
9. Give the theory of torsion pendulum and describe a method to find the moment of Inertia of the disc and the rigidity modulus of the material of a wire using torsion pendulum?
10. Derive an expression for kinetic energy of system of particles.
11. State and prove the theorem of parallel axes and perpendicular axis for the moment of inertia of a rigid body.
12. Derive an expression for angular momentum of a rigid body.
13. Explain conservation of angular momentum with examples.

UNIT II - THERMAL PHYSICS

PART A QUESTIONS

1. Define coefficient of linear expansion.

The coefficient of linear expansion of a solid is the increase in length of unit length of the solid when its temperature is raise by 1K. It is denoted by the letter α.

2. Define superficial expansion.

The coefficient of superficial expansion of a solid is the increase in area produced in unit area of the solid when the temperature is raised by 1 K. It is denoted by the letter β.

3. Define is coefficient of cubical expansion.

Coefficient of cubical expansion of a solid is the increase in volume of unit volume of a solid for 1 K rise of temperature. It is denoted by the letter λ.

4. Define coefficient of apparent expansion of the liquid.

It is the observed increase in volume of unit volume of the liquid per degree Kelvin rise of temperature. It is denoted by λa.

5. Define coefficient of real expansion of liquid.

It is the real increase in volume of unit volume of a liquid per degree Kelvin rise of temperature. It is denoted by λr.

6. What is Expansion joint?

An expansion joint or movement joint is an assembly designed to safely absorb the heat induced expansion or contraction of pipeline, duct or vessel. It helps to hold parts together.

7. What is bimetallic strip?

A bimetallic strip means a strip made of two metals pined together. It is like compound bar. It operates on the principle that different metals have different coefficients of expansion.

8. What is thermal insulation?

It will resist the flow of heat to and from a body. It is a material that reduces the rate of heat flow.

9. Define refrigerator.

It is a machine which produced cold. It is used to remove heat from the refrigerated space and reject it to atmosphere. Hence, it maintains the temperature below the surrounding atmosphere.

10. What are heat exchangers?

They are devices used to transfer heat between two or more fluid streams at different temperatures.

11. Define oven.

An oven is thermally insulated chamber used for heating, baking or drying of a substance and most commonly used for cooking Kilns and furnaces are special-purpose ovens, used in pottery and metalworking, respectively.

12. What is solar power?

The energy (heat and light) obtained from the sun, is called solar energy. Sun is the source of all energy. Sunlight contains infrared radiations in large proportion, and these infrared rays heats all objects on which they fall.

13. What are the basic entities responsible for thermal conduction of a solid?

- Area of cross section (A)
- Temperature difference between the hot and cold layers of the solid (θ_1-θ_2)
- Time of Conduction (t)
- Thickness of the solid (x)

14. Define Coefficient of thermal conductivity?

The Coefficient of thermal conductivity is defined as the amount of heat conducted per second normally across the unit area of cross section, maintained at unit temperature gradient. $\text{Thermal diffusivity }(h) = \text{Thermal Conductivity} / \text{Thermal Capacity}$

15. Distinguish between conduction and convection?

Conduction: It is the process in which the heat is transferred from hot end to cold end without the actual movement of the particles.

Convection: It is the process in which the heat is transmitted from hot end to cold end without the actual movement of the particles.

16. Define Radiation and give example.

It is the process in which the heat is transmitted from one place to another without the necessity of the intervening medium.

Example: The rays from the Sun reflect the Earth.

17. What is meant by Temperature gradient?

The rate of fall of temperature with respect to the distance is called as **temperature gradient.** In general, it is denoted as $-d\theta/dx$. The negative sign indicates the fall of the temperature with increases in distance.

18. Define thermal diffusivity.

It is defined as the ratio of thermal conductivity to the thermal capacity per unit volume of the material $\text{Thermal diffusivity}\,(h) = \text{Thermal Conductivity} / \text{Thermal Capacity}$

Since thermal capacity is the product of specific heat capacity(s) and density of the material (ρ), we can write $h = k / \rho s \; m^2 s^{-1}$

19. Derive the unit for Thermal Conductivity?

The Thermal Conductivity of the material is $K = Qx / A\,(\theta 1 - \theta 2)\,t$

The unit of thermal Conductivity is $Wm^{-1}K^{-1}$

20. Give the methods of determining the thermal conductivity of good and bad conductors.

The methods of determining the thermal conductivity of good and bad conductors are:

- Searle's Method–Good conductors like metallic rod
- Forbes's method–for determining absolute conductivity of metals
- Lee's disc method–for bad conductors
- Radial flow method-for bad conductors

22. What is the basic principle employed in lee's disc Method for bad conductor?

The given bad conductor is taken in the form of disc and is placed in between the disc and the chamber. The steam is passed through bad conductor. 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. When steady state is reached,

The amount of heat conducted through bad conductor per sec=Amount of heat lost per sec by the disc.

21. Why the specimen used to determine thermal conductivity of a bad conductor should have larger area and smaller thickness?

For bad conductor with a smaller thickness and larger area of cross section, the amount of heat conducted will be more.

22. What is meant by thermal resistance?

The thermal resistance of a body is measure of its opposition to the flow of heat through it. (i.e.) everybody possesses some resistive power when it is subjected to heat. This resistive power is termed as thermal resistance.

23. Give the principle of solar water heater.

Solar water heater is based on the principle of converting solar energy (sunlight) into electrical energy and then into heat energy, using solar electric panels, so called solar cells. Nowadays solar thermal panels were widely used , which converts solar energy directly into heat energy.

24. What is a cryogenic material?

A cryogenic material is a material at a very low (or 'cryogenic') temperature. This includes liquids and solids such as cardice. Cryogenic liquids are gases at normal temperature and pressure that are liquefied at very low temperatures. Examples include nitrogen, argon and helium.

25. Define tempered glass.

Tempered or toughened glass is a type of safety glass processed by controlled thermal or chemical treatments to increase its strength compared with normal glass. Tempering puts the outer surfaces into compression and the interior into tension.

PART B QUESTIONS

1. Explain some practical uses of thermal expansion of substances?
2. Describe the Forbes method to determine the thermal conductivity of good conductor
3. Derive an expression for the quantity of heat flow through a metal slab whose faces are kept at two different temperatures. Use this expression to determine the thermal conductivity of a bad conductor by Lee's disc method.
4. Derive an expression for the flow of heat through a compound media in series and parallel.
5. Describe the principle, construction and working of solar water heater. Mention any two advantages and disadvantages of it.
6. Write short notes on a) Tempered glass b) Cryogenic materials

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UNIT III- SOUND WAVES AND VIBRATIONS

PART A QUESTIONS

1. What are factors affecting the acoustic quality of a building?

- Reverberation time
- Focusing and interference
- Echoes and Echelon effect
- Resonance
- Extraneous noise

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

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

The absorption coefficient can also be defined as the rate of sound energy absorbed by a certain area of the 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 of the work. It sometimes affects the nervous system and lowers the restorative quality of sleep, some strong noises lead to damage 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 the 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 (IL) is equal to the difference in loudness, which is given by

$$I_L = L_1 - L_0$$
$$= K \log_{10} I_1 - K \log_{10} I_0$$
$$\therefore I_L = K \log_{10}(I_1 / I_0)$$

Where, 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. Unit for intensity level is Bel.

8. Mention any four sound absorbing materials?

(1)Wooden floor (2) Glass (3) Carpets (4) Felt

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 be made louder by the following ways,

The size of the blade can be increased

A Resonant body should be kept near the vibrating blade 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?

Sl. No.	Loudness	Intensity
1.	It is degree of sensation. It is produced in the ear.	It is the energy of sound wave crossing per unit time through a unit area at right angles to the direction of propagation.
2.	It is physiological quantity	It is purely 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 standard unit used to measure the loudness. One decibel is equal to one tenth of bel.

Phon: The measure of loudness is phon of any sound is equal to the loudness is 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 from one millionth of its original intensity, after the source of sound is stopped.

The reverberation time can be related as $T = \frac{0.16V}{\Sigma aS}$

Where, V is the volume of the hall, a is the average absorption coefficient and S is the total surface area

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 echoes (or) inaudibility.

For concert halls it should be 0.5 seconds.

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.

The Sabine's Law can be used to calculate the reverberations time of an auditorium. It is also used to find the absorption coefficient of any unknown material.

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 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 Resonance.

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

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

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.

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

Resonance should be avoided and noises should be reduced.

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

19. Name the methods by which ultrasonic waves are produced.

In general, there are three methods of producing ultrasonic waves. They are Mechanical generators (or) Galton's Whistle method, Magnetostriction method and Piezo – electric method.

20. Are ultrasonics waves electromagnetic waves? Give proper reasons to your answer.

Ultrasonic waves are not electromagnetic waves because they are sound waves, which does not consist electric and magnetic vectors as in electromagnetic waves.

21. What are the disadvantages of Magnetostriction oscillator?

It can produce frequencies up to 3 MHz (3 x10^6Hz) only
It cannot withstand at high temperatures, since the frequency of oscillation depends greatly on temperature, and
There will be loss of energy due to hysteresis and eddy current during the frequency of oscillations.

22. What is the main difference in the quality of ultrasonic waves produced by Piezo – electric and Magnetostriction method?

S.No	Piezo – electric method	Magnetostriction method
1	It generates very high frequencies (500MHz).	It generates low frequency ultrasonic waves (3 MHz).
2	We can obtain constant frequency of ultrasonic waves.	We cannot obtain constant frequency of ultrasonic waves.
3	The peak of resonance curve is narrow.	The peak of resonance curve is broad.
4	Frequency of oscillation is independent of temperature.	Frequency of oscillation is depends of temperature.

23. Mention the properties of Ultrasonics.

- The frequency of an ultrasonic wave is greater than 20,000 Hz.
- It travels longer distance in the medium without any loss.
- It travels as well-defined sonic beam.
- Its velocity is constant for a homogeneous medium.
- It has a many modes of vibrations such as longitudinal, shear and different modes of surface vibrations.
- It undergoes reflection and refraction at the interface, due to the change in elastic and physical properties of the medium.

24. Why not Ultrasonics be produced by passing high frequency alternating current through a loud speaker?

At such high frequencies inductive react and is so high that no current flows through the coil of the loud speaker and hence, ultrasonic waves cannot be produced.

25. What is Magnetostriction effect? (or) What is the basic principle of Magnetostriction generator?

When a magnetic field is applied parallel to the length of ferromagnetic rod made of materials such as iron or nickel makes its length changes. This effect is known as Magnetostriction effect. Nickels, alloys of nickel and cobalt ferrites are widely used as magnetostrictive materials.

26. Give important applications of Ultrasonics.

- Detection of flaws in metals.
- SONAR for detection of submarines, ice bars and other objects in ocean.
- Soldering and metal cutting.
- Bloodless surgery in medicine.
- Diagnostic applications such as detection of tumors and other defects in human body, and
- Ultrasonic Doppler technique to measure the flow of velocity of blood in different parts of the body.

27. What are the merits of piezo – electric oscillator?

- It is more effective than Magnetostriction oscillator. Almost all the modern ultrasonic generators are of this type only.
- Ultrasonic frequencies as high as 5×10^8 or 500 MHz can be obtained with this arrangement
- The output of this oscillator is very high, and
- The oscillator is not affected by temperature and humidity.

28. What are the demerits of the piezo – electric oscillator?

Piezo – electric crystals are very expensive and
Cutting and shaping the piezo electric crystal are not easy.

29. What is an acoustic grating?

When ultrasonic waves travel through a transparent liquid, due to alternating compression and rarefaction, longitudinal stationary waves are formed in a liquid, it serves as a diffraction grating called acoustic grating.

30. What are ultrasonic waves?

Sound waves having frequency greater than 20 KHz are called ultrasonic waves.

31. What is piezo-electric effect?

When pressure is applied to one pair of opposite faces of crystals like quartz, equal and opposite charges appear across its other opposite faces. This is known as piezo-electric effect.

32. What is Phonocardiogram?

Phonocardiogram is an instrument, which graphically records the heart sound. The presences of higher frequencies in the phonocardiogram indicate a possible heart disorder.

33. Where is the transducer placed for the echocardiography?

The transducer is placed between the third and fourth ribs on the chest wall, where there is no lung between the skin and the heart.

34. Give some of the important industrial application ultrasonic.

- Ultrasonic drilling
- Ultrasonic welding
- Ultrasonic soldering
- Ultrasonic flaw detection
- Ultrasonic thickness determination, and
- Ultrasonic cleaning.

PART B QUESTIONS

1. Derive an expression for the reverberation period of an auditorium and explain how this can be used for determining the absorbing power of surface involved.

2. Write in detail about the factors affecting architectural acoustics and their remedies.

3. Discuss the salient points associated with acoustics of auditorium.

4. Discuss the factors, reverberation, resonance, echelon effect, focusing and reflection that affect the acoustics in hall and the remedies for them.

5. The volume of a room is 1500 m^3. The wall area of the room is 260 m^2, the floor area is 140^2 and the ceiling area is 140 m^2. The average sound absorption co-efficient for wall is 0.03, for the ceiling is 0.80 and for the floor is 0.06. Calculate the average absorption co-efficient and the reverberation time.

6. What is reverberation time? Using Sabine's formula explains how the sound absorption coefficient of material is determined.

7. Derive the expressions for growth and decay of sound energy.

8. Define reverberation time and absorption coefficient.

9. Derive Sabine's formula for the Reverberation time of a Hall.

10. Derive expressions for growth and decay of energy density inside a hall and hence deduce Sabine's formula for the reverberation time of the hall.

11. Describe Piezo electric method of producing ultrasonic waves.

12. Explain how ultrasonic waves can be produced by using Piezo electric crystal and write any four applications of Ultrasonics.

13. What are Magnetostriction and Piezo electric effects? Write down the complete experimental procedure with a neat circuit diagram of producing ultrasonic waves by Magnetostriction effect.

14. Describe the production of ultrasonic waves by Magnetostriction or Piezo electric method and mention some of its applications.

15. Describe the method to produce ultrasonic.

16. What are the applications of Ultrasonics in industry?

17. What are ultrasonic waves? Explain with neat circuit, the generation of ultrasonic waves using piezo electric piezo electric oscillator.

18. Define Magnetostriction effect and explain how it can be applied for the production of Ultrasonics using Magnetostriction oscillator.

19. Explain with neat sketch, the construction and production of ultrasonic waves using Piezoelectric oscillator.

20. Give the application of Ultrasonics in engineering field.

PART A QUESTIONS

1. Define unit cell.

The unit cell is defined as the smallest geometric figure, the reception of which gives the actual crystal structure. The unit cell is also defined as fundamental elementary pattern of minimum of atoms, molecules or groups of molecules which represent fully all the characteristic of the crystal.

2. What are Miller indices?

Miller indices are a system with a set of three numbers within parenthesis to designate a plane in a crystal. This set of three numbers is known as Miller indices of the plane. Crystal direction is represented as a set of three numbers within the square bracket.

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

3. Define space (or) crystal lattice.

The three dimensional space lattice is defined as an infinite array of imaginary points in space such that every point has surroundings identical to that of every other point in the array. Each point in the space lattice is called lattice points.

4. Bismuth has a=b=c=4.7 Å and angles α=β=γ=60°. What is its crystal structure?

Since a=b=c and α=β=γ, crystal structure of Bismuth is Trigonal or Rhombohedral.

5. What is primitive cell?

A primitive cell is the smallest unit cell all in volume constructed by primitive only one full atom.

6. What are Bravais lattices?

According to Bravais, there are fourteen possible independent ways of arranging points in three dimensional space. These fourteen possible space lattices of the seven crystal systems are called Bravais lattices.

7. Define packing factor (or) packing density (or) density of packing and give its unit.

The packing density is the ratio between the total volume occupied by the atoms or molecules in an unit and the volume of the unit cell.

$$\text{i.e., packing density} = \frac{\text{Total volume occupied by atoms in a unit cell}}{\text{Volume of the unit cell}}$$

$$= \frac{\text{Number of atoms present in unit cell * volume of atom}}{\text{Volume of the unit cell}}$$

Since, atomic packing factor is the ratio; it does not have any unit.

8. What are the lattice parameters of a unit cell?

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

9. Name the seven crystal systems.

The seven crystal systems are as follows:

(i) Cubic
(ii) Tetragonal

(iii) Orthorhombic
(iv) Monoclinic
(v) Triclinic
(vi) Trigonal, and
(vii) Hexagonal.

10. Define coordination number.

The coordination number of an atom in a crystal is the number of nearest atoms directly surrounding with that atom. If the coordination number is high, then the structure will be more closely packed. It signifies the tightness of packing of atoms in the crystal.

11. Define atomic radius.

Atomic radius is defined as half of the distance between any two nearest neighbor atoms that have direct contact with each other, in a crystal of a pure element. It is usually expressed in terms of cube edge a (lattice parameter).

12. Calculate the packing factor of simple cubic (sc) crystal structure.

$$\text{Packing factor} = \frac{\text{Number of atoms present in unit cell x Volume of atom}}{\text{Volume of the unit cell}}$$

$$= \frac{1x\,(4/3)\,\pi r^3}{a^3}$$

We know, r = a /2, therefore,

$$\text{Packing factor} = \frac{(4/3)\,\pi a^3}{8\,a^3}$$

$$= \pi/6$$

PF = 0.52

13. Calculate the packing factor of body centered cubic (bcc) crystal structure.

The number of atoms present in a unit cell =2 atoms

$$\text{Packing factor} = \frac{\text{Number of atoms present in unit cell x Volume of the unit cell}}{\text{Volume of the unit cell}}$$

$$= \frac{2x\,(4/3)\,\pi r3}{a^3}$$

We know, $r = \frac{\sqrt{3}}{4} a$, therefore,

$$\text{Packing factor} = \frac{2x\,(4/3)\,\pi\,(\sqrt{3}/4\;a\,)^3}{a^3}$$

$$= \frac{\sqrt{3}\,\pi}{8}$$

PF = 0.68

14. Calculating the packing factor of face centered cubic (fcc) crystal structure.

The number of atoms present in an fcc unit cell is four. Therefore, the packing factor of the fcc unit cell can be written as,

$$\text{Packing factor} = \frac{4[\,(4/3)\,\pi\,r^3]}{a^3}$$

We know, atomic radius $r = a / 2\sqrt{2}$

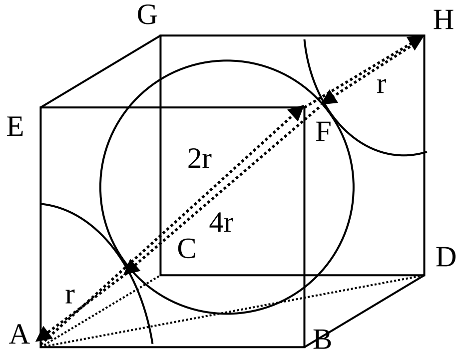
$$\text{Therefore, Packing factor} = \frac{4x\,(4/3)\,\pi\,(a / 2\sqrt{2})^3}{a^3}$$

$$PF = \pi / 3\sqrt{2} = 0.74$$

15. Calculate the atomic radius for body centered cubic (BCC) structure.

For a body centered unit cell, the atomic radius can be calculated from the above figure as follows: AH = 4r and DH = a

From the triangle AHD,



$$AH^2 = AD^2 + DH^2$$

From the triangle ABD,

$$AD^2 = AB^2 + BD^2$$

$$AD^2 = a^2 + a^2$$

$$AD = \sqrt{2}\, a$$

Substitute equation (2) in equation (1),

$$AH^2 = 2a^2 + a^2$$

$$(4r)^2 = 3a^2$$

$$r^2 = \frac{3a^2}{16}$$

The atomic radius $r = \frac{\sqrt{3}a}{4}$

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

$$\text{Density } \rho = \frac{\text{(Number of atoms per unit cell) x (atomic weight)}}{\text{(Avogadro's number) x (lattice constant)}^3}$$

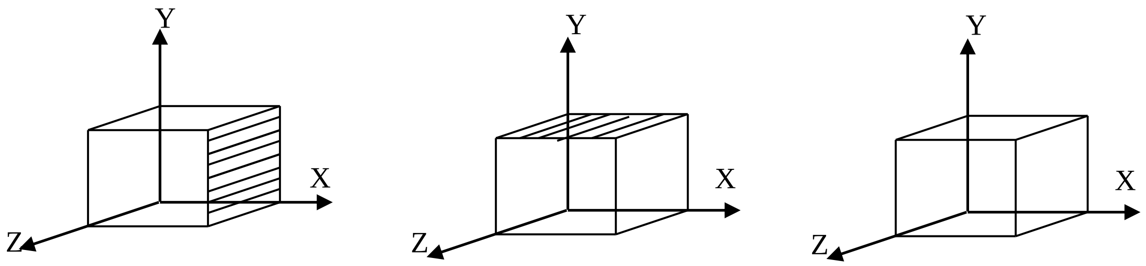
$$\rho = \frac{nA}{Na^3}$$

17.State the expression for interplanar spacing for a cubic system interms of lattice constant and Miller indices.

The interplanar distance (d) = $a / \sqrt{h^2+k^2+l^2}$

Where, a is lattice constant
h, k, l are Miller indices.

18.Sketch (10 0), (0 1 0) and (1 1 1) planes for a cubic crystal.



(a) (1 0 0)plane (b) (0 1 0)plane (c) (1 1 1)plane

19.What is a crystal structure?

A basis is an assembly of atoms identical in composition, arrangement and orientation. When the basis is repeated with correct periodicity in all directions, it gives actual crystal structure.

Thus, Space lattice + Basis ⇒ Crystal structure.

20. Name the crystalline structure of the following:
(a) Gold, (b) Germanium, (c) Barium and (d) Zinc

(a) Gold - fcc
(b) Germanium - Diamond
(c) Barium - bcc

21.What are crystalline materials?

The materials, which have a regular and periodical arrangement of atoms in a solid, are known as crystalline materials.

22.Classify the crystalline materials.

A crystalline material is classified into two categories.

- Single crystals
- Poly crystals.

23.What is non-crystalline or amorphous solid? Give examples.

The materials in which the atoms in solid are arranged in an irregular pattern are known as non-crystalline or amorphous materials.

Examples: Plastic and rubber.

24.Differentiate crystalline and non-crystalline materials.

S.No	Crystalline Materials	Non-Crystalline Materials
1.	They are isotropic	They are anisotropic.
2.	They have a definite and regular geometrical shape.	They don't have definite geometrical shape.
3.	They are most stable.	They are less stable.
4.	Examples: NaCl and KCl	Plastic and glass.

25.Define inter atomic and Interplanar distance.

The distance between any two atoms is called inter atomic distance. The distance between any two planes is called interplanar distance.

26.Give the number of atoms, coordination number and packing density of unit diamond cell.

Number of atom per unit cell = 8 atoms
Coordination of number = 4
Packing density =34%

27.Graphite acts as good conductor but diamond does not conduct an electric current. Why?

In diamond all four outer electrons of each carbon atom are 'localised' between the atoms in covalent bonding. The movement of electrons is restricted and diamond does not conduct an electric current. In graphite, each carbon atom uses only 3 of its 4 outer energy level electrons in covalently bonding to three other carbon atoms in a plane. Each carbon atom contributes one electron to a delocalised system of electrons that is also a part of the chemical bonding. The delocalised electrons are free to move throughout the plane. For this reason, graphite conducts electricity along the planets of carbon atoms, but does not conduct in a direction at right angles to the plane.

28. State the conditions imposed on the cell parameters for crystal systems having the largest of bravais lattices and the least number of nearest neighbors.

(i) System having the largest number of Bravais lattices is orthorhombic. Its cell parameters are: $a \neq b \neq c$; $\alpha = \beta = \gamma = 90^o$

(ii) System having the least number of nearest neighbors is diamond cubic (4). Its cell parameters are: $a = b = c$; $\alpha = \beta = \gamma = 90^o$.

29. Write the different types of crystal defects.

(i) Point defects (zero dimensional)

(a) Impurity defect

(i) Substitutional impurity defect

(ii) Interstitial impurity defect

(b) Vacancies

(i) Frenkel defect

(ii) Schottky defect

(ii) Line defects (one dimensional)

(a) Edge dislocation

(b) Screw dislocation

(iii) Surface defects (two dimensional)

(a) Grain boundaries

(b) Twin boundaries

(c) Tilt boundaries

(d) Stacking faults

(e) Ferromagnetic domain walls

(iv)Volume defects (three dimensional)

(a) Cavities or voids

(b) Cracks and holes

30. Define line defect.

The defect along a line is called line defect. There are two types of line defects

(i) Edge dislocation and

(ii) Screw dislocation.

31. Distinguish edge and screw dislocations.

An edge dislocation arises when one of the atomic planes forms only partially and does not extend through the entire crystal.

Screw dislocation is due to a displacement of atoms in one part of a crystal relative to rest of the crystal.

32. What are Burgers vector.

The magnitude and the direction of the displacement due to edge dislocation are defined by a vector called Burger's Vector.

33. What is crystal defect?

The deviation from the regularity of arrangement of atoms is called crystal imperfection or crystal defect.

34. What is impurity defect? What are types of impurity defects?

A foreign substance added to a crystal is called impurity. The impurity atom may fit in the structure in two ways giving rise to two kinds of impurity defects.

(i) Substitution impurity defect

(ii) Interstitial impurity defect.

35. What are vacancies?

Vacancies are empty atomic sites. Vacancies may occur as a result of imperfect packing during the original crystallization or they may arise from the thermal vibrations of atoms at higher temperatures.

There are different kinds of vacancies like Frenkel defect, Schottky defect, Colour centers etc.

36. What is Frenkel defect?

A vacancy associated with interstitial impurity is called Frenkel defect.

37. What is Schottky defect?

If an atom is missing from its lattice site, the vacancy is called Schottky defect.

38. What are twin boundaries?

If the atomic arrangement on one side of the boundary is the mirror image of the arrangement on the other side the defect is called twin boundaries.

39. What is stacking fault?

This defect arises due to defect in the stacking of atomic planes. In some cases a part of certain atomic plane will be missing where as in some other cases a portion of extra atomic plane is present, changing the sequence of arrangement of atoms.

PART B QUESTIONS

1. Show that the packing factor for FCC and HCP are equal.

2. (i)Define packing factor of a unit cell
(ii) Obtain the expression for packing factor of face centered cubic and body centered cubic unit cells.

3. Derive an expression for the packing factor of copper. What do you infer from that?

4. (i) Explain the term atomic radius, co-ordination number and packing factor.
(ii) Determine the atomic radius, co-ordination number and packing factor for BCC, FCC and diamond structures.

5. Explain the various types of crystal systems with a neat sketch and example.

6. (i) Explain the following terms: (a) Space lattice (b) basis (c) unit cell
(ii) Define the terms atomic radius and packing factor. Calculate the above for SC, BCC and FCC structures.

7. Explain the characteristics of a unit cell of the simple cubic system.

8. Explain the characteristics of a unit cell of the body centered cubic system.

9. Explain the characteristics of a unit cell of the face centered cubic system.

10. Describe the structure of HCP crystal. Obtain the relation between c and a and hence calculate the atomic packing factor.

11. What are Miller indices? Explain how they are determined with any two planes in SC structure. Give their significance.

12. What are Miller indices? Sketch two successive (110) planes. Show that for a cubic lattice the distance between two successive plane (hkl) is given by

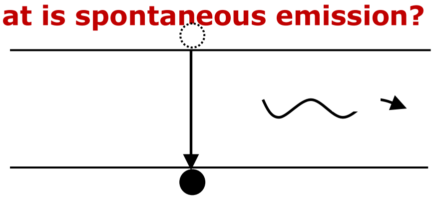
$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

13. Explain the physical basis of classifying crystals into 7 systems and 14 bravais lattices.

14. Explain in detail the different types of line and surface defects.

PART A QUESTIONS

1. What is spontaneous emission?

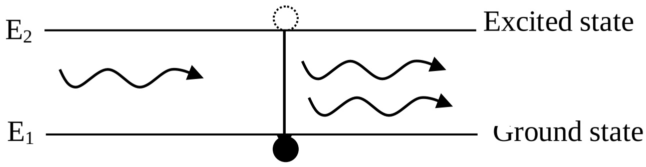


The atom in the excited state E_2 (higher energy state), returns to the ground state E_1 (lower energy state), by emitting a photon of energy h© without the action of an external energy. Such an emission of radiation which is not triggered by an external influence is called spontaneous emission.

2. What is stimulated emission?

The process of forced emission of photons caused by the incident photons is called stimulated emission. It is also called induced emission. This process is the key factor to the operation of a laser.

3. What is pumping emission?



Pumping is the process of raising more number of atoms to excited state by artificial means is called as pumping process. There are several methods by which the population inversion (pumping) can be achieved.

4. What are the pumping methods are available?

Some of the commonly used methods are:

Optical pumping
Direct electron excitation or electric discharge
Inelastic atom-atom collision method
Direct conversion method, and
Chemical method.

5. What is meant by population inversion and how it is achieved?

Establishment of a situation in which number of atoms in higher energy state is greater than that in lower energy state is called population inversion. For normal situation, the number of atoms N_2 i.e., population of higher energy state is much lesser than the population of lower energy state N_1, i.e., $N_1 > N_2$. The phenomenon of making $N_2 > N_1$ i.e., the number of atoms N_2 in higher energy state is more than the number of atoms N_1 in lower energy state is called population inversion or inverted population. Population inversion can be achieved by means of pumping action.

6. State the properties or characteristics of laser beam.

The most important features or characteristics of lasers are:

- Directionality
- High intensity
- Extraordinary monochromacity, and
- High degree of coherence

7. Distinguish between ordinary and laser beam.

S.N	Ordinary light	Laser light
1.	In ordinary light angular spread is more	In laser beam 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 coherent beam and is in phase
5.	The radiations are polychromatic	The radiations are non-polychromatic
6.	Examples: Sunlight, mercury vapour lamp etc.	Examples: He-Ne laser, CO_2 laser etc.

8. What are Einstein's relations or coefficients?

In Einstein's theory of spontaneous emission and stimulated emission, we have,

$$B_{21} = B_{12}$$

$$A_{21} / B_{21} = 8\pi h\gamma^3 / c^3$$

Where, A_{21}, B_{12} and B_{21} are three constants known as Einstein's coefficients

9. What are the differences between stimulated and spontaneous emission of radiations?

S. N	Stimulated emission	Spontaneous emission
1.	Atom in the excited state is induced to return to ground state, thereby resulting in two photons of same frequency and energy is called stimulated emission.	The atom in the excited state returns to ground state thereby emitting a photon, without any external force is called spontaneous emission.
2.	The emitted photons move in the same directions and are highly directional.	The emitted photons move in all directions and are random.
3.	The radiation is high intense, monochromatic and coherence.	The radiation is less intense and is incoherent.
4.	The photons are in phase i.e., there is a constant phase difference.	The photons are not in phase i.e., there is no phase relationship between them.

10. What is the principle of LASER??

Due to stimulated emission, the photons multiply in each step giving rise to an intense beam of photons that are coherent and moving in the same direction. Hence, the light is amplified by stimulated emission of radiation, termed as LASER.

11. Explain metastable state.

Any atom can be excited to a higher level by the absorption of energy. Normally, excited atoms have short lifetimes (10^{-9} seconds) through spontaneous emission. In order to establish the condition of population inversion, the excited atoms are required for longer lifetime. A metastable state is such a state. Atoms excited to metastable states remain excited for an appreciable time, which is of the order of 10^{-6} to 10^{-3} seconds. There could be no population inversion and hence no laser action, if metastable does not exist.

12. What are three basic requirements for the systems?

All the laser systems must satisfy the following basic requirements for laser operation: Active medium, Pumping system and Optical resonator.

13. What are the different types of laser available?

Lasers are classified into five major categories based on the types of active medium.

1. Solid state laser; **Examples**: Ruby laser, Nd-YAG laser
2. Gas laser; **Examples**: CO_2 laser
3. Semiconductor laser; **Examples**: GaAs laser
4. Liquid laser; **Examples**: Europium benzoleacetonate dissolved in alchohol, $SeOl_2$ laser
5. Dye & chemical laser; **Examples**: Rhodamine 6G laser and Coumarin dye laser.

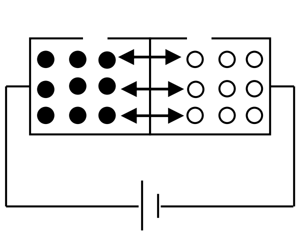
14. What are the applications of carbondioxide laser?

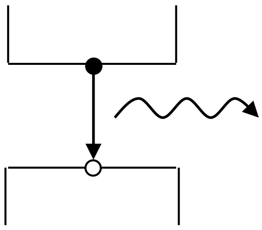
Due to their high power levels, CO2 lasers are commonly used in material processing applications, particularly for cutting die boards, metals, plastic, etc, welding metals such as copper, aluminum or stainless steel, and laser marking of different materials.

15. What are the applications of Helium Neon laser?

- He-Ne laser is mainly used in making holograms.
- In laser printing He-Ne laser is used as a source for writing on the photosensitive material.
- He-Ne lasers were used in reading Bar Codes, which are imprinted on products in stores.

16. What is the principle of semiconductor diode laser?





When p-n junction diode is forward biased, electrons from n region and holes from p region recombine with each other at the junction. During recombination process, light is released from certain specified direct band gap semiconductors like Gallium Arsenide. This radiation is called recombination radiation. The corresponding energy is called activation energy. The wavelength of the light emitted depends on the activation energy. The photons emitted during recombination stimulate other changes and as a result, stimulated emission takes place which leads to laser light.

17. How the light emitting diode different from a semiconductor laser?

S.No.	LED	LASER
1.	It requires low current density	It requires high current density
2.	Junction of diode need not be polished	Junction of the diode should be highly polished
3.	Minority carrier injection should take place	Stimulated emission will take place
4.	Power output is low	Power output is high
5.	Intensity is less	Intensity is very high.

18. List the basic components of the oscillator.

All the laser systems must satisfy the following basic requirements for laser operations:
1. Active medium, 2.Pumping system, and 3.Optical resonator.

19. What is optical fiber?

Optical fiber is a wave guide, made up of transparent dielectric like glass or plastics in cylindrical form through which light is transmitted by total internal reflection. An optical fiber consists of a central core glass about 50 μm diameter surrounded by cladding about 125 μm to 200 μm diameter which is slightly lower refractive index than core material i.e., $n_1 > n_2$.

20. Define acceptance angle.

Acceptance angle (θ_A) may be defined as the maximum angle that a light ray can have relative to the axis of the fiber and propagate down the fiber.

21. Define fiber optics.

Fiber optics is defined as it is a branch of physics which deals with the transmission and reception of light waves using optical fiber as wave guides.

22. What are the conditions to obtain total internal reflection?

The phenomenon of total internal reflection takes place when it satisfies the following conditions:

Light should travel from denser medium to rarer medium, i.e., $n_1 > n_2$
Where, n_1 is the refractive index of core; n_2 is the refractive index of the cladding material.

The angle of incidence on core should be greater than the critical angle, i.e., $\varphi > \varphi_c$
Where, φ is the angle of incidence and φ_c is the critical angle.

23. What are the features or advantages of Optical fibers?

- It is light in weight.
- It is smaller in size and is flexible.
- It is non-conductive and non-radiative.
- It has high bandwidth and low loss.
- There is no short circuit in fibers.
- There is no internal noise or cross talk.
- It can withstand even at high temperatures.

24. Define numerical aperture of a fiber.

The sine of the acceptance angle ($\sin\theta_A$) of the fiber is known as numerical aperture (NA). It denotes the light gathering capacity of the optical fiber.

i.e., Numerical aperture $(NA) = \sin\theta_A$.

25. What is meant by fractional index change?

The fractional difference Δ between the refractive indices of the core and cladding is known as fractional refractive index change. It is expressed as, $\Delta = n_1 - n_2 / n_1$
This parameter is always positive because n_1 must be larger than n_2 for the total reflection condition.

26. Differentiate between single mode and multi mode fiber.

S.No.	Single mode fiber	Multi-mode fibers
1	In single mode fiber only one mode can propagate through the fiber	Multi-mode fiber allows a large number of modes for the light rays traveling through

		it.
2	It has smaller core dia and the difference between the refractive index of the core and cladding is very small	It has larger core dia and refractive index difference is larger than the single mode fiber.
3	No dispersion i.e., degradation of signals during travel in fiber	There is signal degradation due to multi mode dispersion
4	Fabrication is difficult and costly	Fabrication is less difficult and not costly

27. What is single mode fiber?

In a fiber, if only one mode is transmitted through it, then it is said to be a single mode fiber.

28. What is multi-mode fiber?

If more than one mode is transmitted through optical fibers, then it is said to be a multi-mode fiber.

29. What is attenuation?

Attenuation in fibers means loss of optical power suffered by the optical signal in the fiber itself. It is also known as fiber loss or signal loss.

30. Define total internal reflection.

When light ray travels from denser to rarer medium at an angle of incidence greater than critical angle ($\theta_i > \theta_c$), the incident ray is reflected in the same medium that is in denser medium and this phenomenon is called total internal reflection.

31. What is graded index fiber?

The refractive index of the core decreases when the radial distance increases from axis of the core. It is a maximum at the axis and minimum at the core-cladding interface.

32. List out three different types of losses in fiber optics.

Absorption

Rayleigh Scattering and Geometric effects

33. Distinguish between step-index and graded index fibers.

Step index fibers	Graded index fibers
The refractive index of the core is uniform throughout and undergoes step change at the cladding boundary.	The refractive index of the core is made to vary in the parabolic manner such that the maximum refractive index is present at the centre of the core
The diameter of the core is about 50 to 200 μm in the case of multi mode Step index fiber and 10 μm in the case of single mode fiber.	The diameter of the core is about 50 to 200 μm in the case of multi mode fiber.

34. Define dispersion.

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

35. What are the different types of light sources for optical fiber?

Light emitting diodes (LED) and Laser diodes

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

Singular mode fiber - only one mode.
Multi mode fiber - many modes.

37. Why is laser much preferred than LED as a optical source?

Laser light is much preferred than LED it is more directional, highly coherent, faster rise time and narrow spectral width than LED.

PART B QUESTIONS

1. Derive Einstein's relation for stimulated emission and hence explain the existence of stimulated emission.

2. For atomic transitions, derive Einstein relations and hence deduce the expressions for the ratio of spontaneous emission rate to the stimulated rate to the stimulated emission rate.

3. Discuss the various methods employed to achieve population inversion.

4. Explain the construction and working of a semi-conductor diode laser with diagram.

5. Discuss with theory the construction and working of homo-junction semiconductor laser.

6. Explain with basic principle, the construction and working of He – Ne laser.

7. Explain with basic principle, the construction and working of hetero - junction semiconductor laser.

8. Describe the propagation of light through an optical fibre. What are numerical aperture and acceptance angle of a fibre? Explain any two applications of optical fibre.

9. Discuss in detail the basic principle and advantages of optical fibres.

10. Classify the optical fibers on the basis of materials, modes of propagation and refractive index difference.

11. Derive an expression for Numerical aperture and angle of acceptance of a fibre in terms of refractive indices of the core and cladding.

12. Discuss the mechanisms of attenuation, dispersion and bending losses in optical fibres.

13. Explain how optical fibre is used in communication field with block diagram.

14. Explain the principle and working of Fibre Optic Endoscope.

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