

UNIT II

WAVES AND FIBRE OPTICS

1. Explain 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.

2. What are the conditions required for laser action?

- Population inversion should be achieved.
- Stimulated emission should be predominant over spontaneous emission.
- Higher energy state should have a longer mean life time i.e., it should be a metastable.

3. What you mean by population inversion?

In general the number of atoms in the ground state will be more than that of the atoms in the excited state and is called as usual population. The reverse of this (i.e.) a state of achieving more number of atoms in the lower energy level is called as population inversion.

4. What is meant by optical resonator (or) Resonance cavity?

An optical resonator is a feedback system. It consists of an active medium kept in between a 100% mirror and a partial mirror. The intensity of light is increased by bounce back and forth between the mirrors. Finally, the laser beam comes through the partial mirrors.

5. Write the Difference between Spontaneous and Stimulated emission?

S.No	Spontaneous emission	Stimulated emission
1.	The atom in the excited state returns to the ground state thereby emitting photon, without any external inducement is called as spontaneous emission.	An atom in the excited state is induced to return to ground state thereby resulting in two photons of same frequency and energy is called as stimulated emission.
2.	The emitted photons have move randomly.	The emitted photons move in same direction and are highly directional.
3.	The radiation given out is of less intense and is incoherent.	The radiation is highly intense, monochromatic and coherent.
4.	The photons are not in phase.	The photons are in phase.
5.	The rate of transition is given by $R_{21}(SP) = A_{21}N_2$	The rate of transition is given by $R_{21}(ST) = B_{21}\rho_\nu N_2$
6.	Preparation of testing specimen is often required.	No specimen preparation is required.

6. What is pumping action? What are the pumping methods are available?

The process of raising more number of atoms to excited state by artificial means is called as pumping process.

Some of the commonly used pumping methods are

- i. Optical pumping
- ii. Direct electron excitation (Electron exchange)
- iii. Inelastic atom – atom collision
- iv. Direct conversion
- v. Chemical process

7. State the properties or characteristics of laser beam.

The most striking features lasers are:

1. Directionality
2. High intensity
3. Extraordinary monochromaticity
4. High degree of coherence

8. What you mean by total internal reflection? And what are the conditions to obtain total internal reflection?

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

The phenomenon of Total internal Reflection takes place when it satisfies the following two conditions.

- (i) light should travel from denser medium to rarer medium

i.e. $n_1 > n_2$

where n_1 - refractive index of core

n_2 - refractive index of cladding

- (ii) The angle of incidence on core should be greater than the critical angle.

i.e. $\phi > \phi_c$

where ϕ – angle of incidence

ϕ_c – critical angle

9. Define acceptance angle and numerical aperture.

Acceptance angle

It is the maximum angle to the axis at which light may enter into the fiber so that it can have total internal reflection inside the fiber.

$$\text{Acceptance angle } (\theta_A) = \sin^{-1} \sqrt{(n_1^2 - n_2^2)}$$

Numerical aperture (NA):

The sine of the acceptance angle of the fiber is known as numerical aperture (NA). it denotes the light gathering capacity of the optical fiber.

$$\text{Numerical aperture (NA)} = \sin \theta_A$$

10. What are 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.

11. What is the role of cladding in an optical fiber?

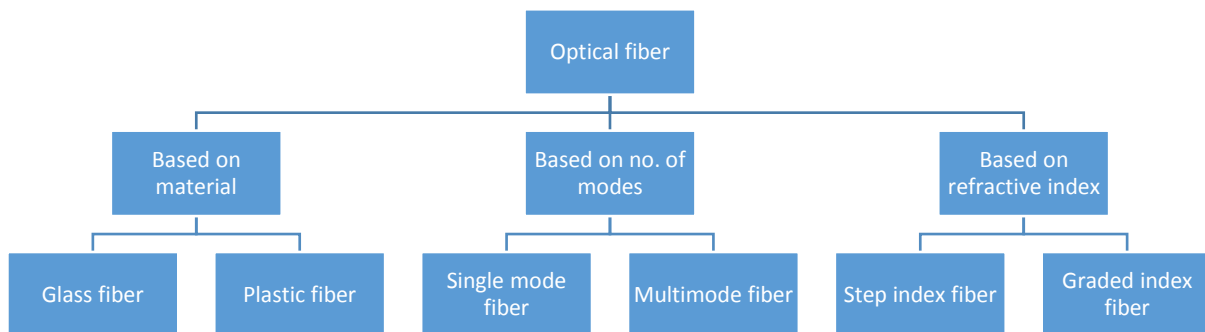
The cladding acts like a mirror, reflecting light back into the core.

12. 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.

$$\text{Attenuation } (\alpha) = -10/L \log(P_{\text{in}}/P_{\text{out}}) \text{ dB/km}$$

13. How will you classify optical fiber?



14. Differentiate between single mode and multimode fiber.

S.No	Single mode fiber	Multimode fiber
1.	Only one mode can propagate through the fiber.	Large number of modes can travel through the fiber.
2.	Smaller core diameter and difference between refractive index of the core and cladding is very small.	Large core diameter and refractive index 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 multimode dispersion.
4.	Information can be carried to longer distances.	Information can be carried to shorter distances only.
5.	Launching of light and connecting the fibers are difficult.	Launching of light and connecting the fibers are easy.
6.	Fabrication is difficult and costly.	Fabrication is easy and not costly.

15. Give any four applications of fiber optic sensors.

- It is used as a fluid level indicator based on the principle of change in refractive index of the medium.
- Optical displacement sensors are used to find the position and displacement of the target.

- Temperature sensors are employed to measure the temperature accurately.
- The laser Doppler velocimeter (LDV) is used to measure several physical quantities such as velocity, fluid surface velocity, vibrations etc.
- The pressure can be accurately measured using the photoelectric pressure sensors.

16. Distinguish between step index and graded index fiber

S.No	Step index fiber	Graded index fiber
1.	The difference in refractive indices between the core and the cladding is obtained in a single step and hence called as step index fiber.	Due to non-uniform refractive indices, their difference in refractive indices between the core and the cladding gradually increases from centre towards interface and hence called graded index fiber.
2.	The light rays propagate as meridinal rays and pass through the fiber.	The light propagation is in the form of skew rays and does not cross the fiber axis.
3.	If follows a Zigzag path of the light propagation.	It follows a Helical path (i.e. spiral manner) of light propagation.
4.	It has a low bandwidth.	It has high bandwidth.
5.	Distortion is more in multimode step index fiber.	Distortion is very less and is almost zero due to self focusing effect.

17. Explain active and passive sensors?

Intrinsic (or) Active sensors:

In active sensors the physical parameter to be sensed directly acts on the fiber itself to produce the changes in the transmission characteristics.

Examples: 1. Temperature or pressure sensors

2. Liquid level sensor

Extrinsic (or) Passive sensors:

In passive sensors, separate sensing element will be used and the fiber will act as a guiding media to the sensors.

Examples: 1. Displacement sensors,

2. Laser Doppler velocimeter sensor

18. Mention the advantages of fibre-optic sensors.

- a. It has no external interference
- b. It is used in remote sensing
- c. Safety of data transfer
- d. It is small in size

19. Mention the properties of detectors and its fiber optics communication

The detectors should possess the following properties, viz

- i. Ability to convert optical signal into electrical signal

- ii. Fast response time
- iii. Zero dark current and
- iv. Cost effective

20. What is meant by endoscope? Mention its uses.

A medical endoscope is a tubular optical instrument used to inspect or view the internal parts of human body which are not visible to the naked eye. The photograph of the internal parts can also be taken using endoscope.