Assignment-4

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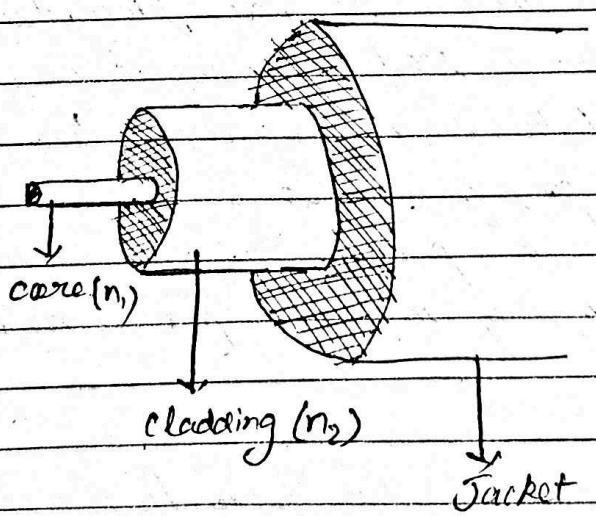
(Question-1)

ans a) Components of optical fibre are:

i) core: central part of the fiber where light signals are transmitted. made up of silica ~~got an~~, glass or plastic

ii) cladding: The layer surrounding the core.

iii) Protective Jacket: layer applied around the cladding, protects from physical damage.



ans b) Acceptance angle: The external angle of incidence made by a ray with the axis of the fibre, corresponding to the critical angle of incidence at the core-cladding boundary, is termed as acceptance angle.

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Acceptance cone:- The acceptance cone is the 3D region around the fiber axis within light can enter and be guided through the fiber. It is defined by the acceptance angle, forming a conical shape.

Numerical Aperture :- It is a number which defines the light acceptance or gathering capacity of a fibre.

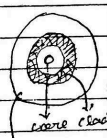
$NA = \sin\alpha$ α = is the acceptance angle.

$NA = \frac{1}{\gamma_0}\sqrt{\gamma_1^2 - \gamma_0^2}$ $NA = \frac{1}{n_0}\sqrt{n_1^2 - n_2^2}$

$n_0 = 1$

Question-2

ans a) In a single mode index fibre, the diameter of the core is very small leading to small acceptance angle and the size of the acceptance cone. Thus only one mode of light can propagate. This singular path eliminates the variation in propagation times associated with different modes, making modal dispersion negligible.



ans b) Relative Refractive Index Difference (Δ) : It measures the difference in refractive index between the core and the cladding of an optical fiber.

It is expressed as a percentage or a fraction indicating how much the core refractive index exceeds that of the cladding.

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$\Delta = \frac{n_1 - n_2}{n_1}$

Relation b/w Relative Refractive index difference and Numerical Aperature.

$NA = n_1\sqrt{2\Delta}$

Question-3

ans a) Scattering loss in optical fiber: refers to the attenuation of light signal strength caused by the scattering of photons due to microscopic variations or impurities in the fiber material.

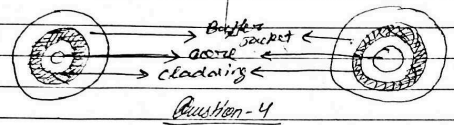
This results in some light being dispersed in directions other than the fiber axis, reducing the transmitted signal.

ans b)

Single mode Step-index fibre	Multi-mode Step-index fibre
• The diameter of the core is very small, it's range is about 5 μm ↔ 10 μm. cladding diameter : 125 μm.	• The diameter of the core is large, it's range is about 30 μm – 100 μm. cladding diameter : 125 ↔ 500 μm.
• Numerical Aperture of SM fibre is small : 0.08 ↔ 0.10	• Numerical aperture of MM fibre is large : 0.12 ↔ 0.5

diagram

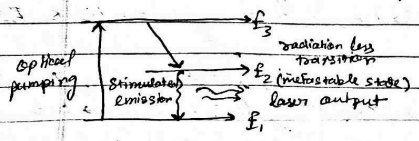
• Modal dispersion is almost nil, material dispersion is low.	• Modal dispersion is dominant source of dispersion, Material dispersion is large.
• It is used for short distance communication.	• It is used for long distance communication.



Question-4

ans a) Spontaneous emission	Stimulated ~~Spontaneous~~ emission
• Emission of a photon by an excited atom or molecule returning to a lower energy state on its own.	• Emission of a photon triggered by an incident photon causing an excited atom or molecule to drop to a lower energy state.
• Incoherent, photons emitted have random phases and directions.	• Coherent, with emitted photons having the same phase, direction, and energy as the incident photon.
• Not used for amplifying light in lasers.	• Essential for laser operation.

Stimulated emission is required for LASER.



Stimulated emission

ans b) Metastable state: refer to excited states of atoms or ions that have longer than usual lifetimes compared to other excited states.

Role in Laser action:

1) It is essential for achieving a population inversion
2) Population inversion occurs when more atoms or ions are in the metastable state than in the lower energy states.
3) This condition is crucial for laser operation, as it allows the buildup of excitation energy, leading to stimulated emission and laser light generation.

Question-5

ans a) Population inversion: is a condition in which more atoms or molecules are in higher energy states (excited states) than in lower energy states (ground state).

- This state is essential for laser action because it allows for stimulated emission to dominate over spontaneous emission.

ans b) Solid state laser: use a solid material (like a crystal or glass) as the active laser medium rather than a gas or liquid.

example: neodymium-doped laser, Ruby lasers.

He-Ne laser	Ruby laser
• wavelength : 6328 Å, which is in the visible spectrum	• wavelength : 6943 Å, lie in red part of the spectrum.
• highly coherent light • Stable in output power and wavelength. • Easy to operate and maintain	• operate in pulsed mode, high peak powers in short bursts. •

conclusion:

While ruby lasers are powerful for pulsed application He-Ne lasers are preferred for their visible wavelength, high coherence, stability, and ease of use in continuous wave operations.