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Questions:-

1. Calculate the ratio of spontaneous to simulated emission by an incandescent lamp at 2000 K (take $\nu = 6 \times 10^{14}$) optical region.

Solⁿ:- Ratio → $\frac{N_1}{N_2} = e^{h\nu/KT}$

Here h = Plank's constant
$= 6.62 \times 10^{-34}$
K = Blozman const.
$= 1.38 \times 10^{-23}$
T = 2000 kelvin
$\nu = 6 \times 10^{14}$ (Given)

$$\frac{N_1}{N_2} = e^{6.62 \times 10^{-34} \times 6 \times 10^{14} / 1.38 \times 10^{-23} \times 2000}$$

$$\frac{N_1}{N_2} = e^{\frac{39.72 \times 10^{-20}}{2.76 \times 10^{-20}}}$$

$$\frac{N_1}{N_2} = e^{\frac{39.72}{2.76}}$$

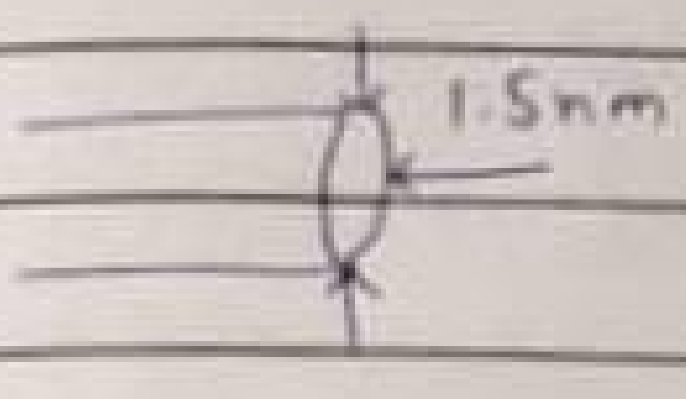
$$\frac{N_1}{N_2} = e^{14.39}$$

$$\frac{N_1}{N_2} = \frac{1776223.43}{1}$$

$$= \boxed{177622343 : 100}$$ Ans

2. Find intensity of laser Beam 20mW and daimeter 1.5 mm. Assume the intensity to be uniform through the Beam.

Sol^n



$$A = \pi r^2 = \frac{\pi D^2}{4} = \frac{\pi \times (1.5)^2}{4}$$

$$A = \left[\frac{\pi \times (1.5)^2}{4} \right] cm^2$$

$P = 20\ mW$ or $0.020W$

$$\because \text{Intensity} = \frac{P}{A} = \frac{0.02}{\frac{\pi \times (1.5)^2}{4}}$$

$$\left[\text{Intensity} = 0.011 \frac{W}{m^2} \right] \text{Ans}$$

3. Calculate the ratio of population of two Energy states of Ruby laser, the transition b/w which responsible for Emission of photon of wavelength 6928 A°. Assume the transition temperature to be 18K.

Sol^n $\lambda = 6928 \times 10^{-10} m$

$T = 18K$

$\because$ we know that

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

$$\Delta E = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6928 \times 10^{-10}}$$

$$\left[\Delta E = 28 \times 10^{-20} \right] kgm^2/s^3$$

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$$\therefore \frac{\Delta E}{kT} = \frac{28 \times 10^{-20}}{1.38 \times 10^{-23} \times 18}$$

$$= \left[1.12 \times 10^{3}\right]$$

$$\therefore \frac{N_2}{N_1} = e^{-1120}$$

$$\left[\frac{N_1}{N_2} = \frac{e^{1120}}{1}\right]$$

$$= \boxed{e^{1120} : 1} \text{ Ans}$$

4. Calculate the ratio of spontaneous Emission to Stimulate Emission of wavelength of radiation emission in 5500A° at 2000K (Given $h = 6.602 \times 10^{-34}$ Js and $k = 1.38 \times 10^{-23}$ S.I. units)

Soln

$\lambda = 5500 \times 10^{-10}$ m
$T = 2000$ K
$k = 1.38 \times 10^{-23}$

$\therefore$ we know that

$$\text{Frequency} = \frac{1}{\text{wavelength}} \times \text{speed of light}$$

$$= \frac{3 \times 10^{8}}{5500 \times 10^{-10}}$$

$$= 0.05 \times 10^{16}$$

$$\left[\nu = 5 \times 10^{14}\right]$$

$$\frac{N_1}{N_2} = e^{5500 \times 10^{-10} \times 5 \times 10^{14} / 2000 \times 1.38 \times 10^{-23}}$$

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$$\frac{N_1}{N_2} = e^{275 \times 10^{6} / 2.76 \times 10^{-20}}$$

$$\simeq \boxed{10^{28}} \quad \text{Ans}$$

or $\boxed{10^{28} : 1}$ Ans

Ans 5. Coherent length (l) = $c \cdot \Delta t$

$c = 3 \times 10^8$ m/s $\qquad \Delta t = 26.7 \times 10^{-9}$ s

$l = 3 \times 10^8 \times 26.7 \times 10^{-9}$

$= 80.1 \times 10^{-1} = 8.01$ m

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6. In a He-Ne laser Beam, the two plane mirrors from the resonate cavity are at a distance are at 0.5m find the mode Separation of longitudinal Cavity in terms of frequency.

Sol

$$2L = \frac{nc}{f}$$

$$f_1 = \frac{nc}{2L} \quad -(1)$$

$$f_2 = \frac{(n+1)c}{2L} \quad -(2)$$

From Eqn (1) and (2)

$$\therefore f_2 - f_1 = \Delta v$$
$$= \frac{nc}{2L} + \frac{c}{2L} - \frac{nc}{2L}$$

$$\left[f_2 - f_1 = \frac{c}{2L} \right]$$

$$\therefore f_2 - f_1 = \frac{3 \times 10^8}{2 \times 0.5} \quad \left[L = 0.5\,m \text{ [Given]} \right]$$

$$= \boxed{3 \times 10^8\ Hz}$$ Ans

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1 An optical fiber has ref. index of core to be 1.5 and relative refractive index diff. of core cladding to be 0.01. Determine the numerical aperture and maxi. angle of acceptance.

Ans :- $NA = \frac{\sqrt{\mu_1^2 - \mu_2^2}}{\mu_0}$ $\mu_0 = 1.5$

$= \frac{\sqrt{0.01}}{1.5} = \frac{1}{15}$

$\therefore \left[NA = \frac{1}{15} \right]$

Max. angle when $\mu_0 = air = 1$

So,

$\sin\theta = \sqrt{0.01}$

$\left[\theta = \sin^{-1}\left(\frac{1}{10}\right) \right]$

or $\cancel{\boxed{\theta = 0.00174^\circ}}$ Ans

$\boxed{\theta = 5.73917^\circ}$ Ans

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8 Ans) $NA = 0.22$

ref. index of core $= n_1$

" " " cladding $= n_2$

Relative ref. index $= 0.012 = \Delta$

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

$$n_1 = \frac{0.22}{\sqrt{2 \times 0.012}}$$

$$n_1 = 1.4201$$

$$n_2 = n_1 (1-\Delta)$$

$$n_2 = (1.4201)(1-0.012)$$

$$= 1.4831$$

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(9). A step index optical fibre has refractive index of $n_2 = 1.458$ and relative index $\Delta = 10\%$ find its critical and maximum angle of acceptance.

Soln Acceptance angle ⇒

$$\sin\theta = \sqrt{n_1^2 - n_2^2} \quad -(1)$$

Numerical acceptance ⇒

$$NA = n_1\sqrt{2\Delta} \quad -(2)$$

$$\text{So,} \quad \Delta = \frac{n_1 - n_2}{n_1}$$

$$10 = \frac{n_1 - 1.458}{n_1}$$

$$10n_1 = n_1 - 1.458$$

$$9n_1 = -1.458$$

$$\left[n_1 = \frac{-1.458}{9}\right] \quad -(3)$$

Putting Eq(3) into (1)

$$\sin\theta = \sqrt{0.026 - 2.125}$$

$$\sin\theta \cong \sqrt{-2}$$

$$\sin\theta = 1.4\,i$$

$$\left[\theta = \sin^{-1}\left(\frac{7}{5}i\right)\right] \text{ Ans}$$

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(11) A silica optical fibre with core diameter large enough to be considered by ray theory analysis has core of ref index of 1.5 and a cladding of ref index 1.47. Det. numerical aperture and angle of acceptance in air for fibre.

Ans Numerical aperture (NA) = $\sqrt{n_1^2 - n_2^2}$

$$= \sqrt{(1.5)^2 - (1.47)^2}$$

$$= \sqrt{2.25 - 2.16}$$

$$= \sqrt{0.09}$$

$$[NA = 0.3]$$

Angle of acceptance ⇒ $\theta = \sin^{-1}\sqrt{(1.5)^2 - (1.47)^2}$

$$= \sin^{-1}(0.3)$$

$$= \boxed{17.45^\circ} \text{ Ans}$$

(12) Compare the maxi. angle of acceptance and NA of two fibers whose core and cladding indexes are n_1 a n_2 to be :-

(a) $n_1 = 1.6$ $n_2 = 1.5$ (b) $n_1 = 2.1$, $n_2 = 1.5$

(a) $NA = \sqrt{n_1^2 - n_2^2}$

$$\sqrt{2.56 - 2.25}$$

$$= \frac{\sqrt{31}}{10} = \frac{5.56}{10} = \boxed{0.55}$$

$$\theta = \sin^{-1}(0.55) = \boxed{33.36^\circ}$$

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(13) Consider the step index fibre with $n_2 = 1.46$ $\Delta = 0.0015$ and radius = a = $5 \mu m$. Show that $\lambda > 1.40 \mu m$, it is a single mode fibre.

Sol

$$V_{num} = \frac{2\pi n a \sqrt{2\Delta}}{\lambda}$$

$$= \frac{2 \times 3.14 \times 1.46 \times 5 \times \sqrt{2 \times 0.0015}}{1.5}$$

$$= 30.56 \times \sqrt{0.003}$$

$$= 30.56 \times \frac{1.732}{\sqrt{1000}}$$

$$\cdot V_{num} = 1.732$$

which is less than 2.405

So, it is Single mode optical fibre.

Hence proved.

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(b) $NA = \sqrt{n_1^2 - n_2^2}$

$= \sqrt{4.41 - 2.25}$

$= \sqrt{2.16}$

$= \frac{\sqrt{216}}{10} = \cancel{14.6}\ 1.4$

$\cancel{\theta = \sin^{-1}(14.6) =}$

$[\theta \cong 90°]$

Q-14 Two step index fiber are char. by (a) $n_1 = 1.5$ $n_2 = 1.49$ (b) 1.5 $n_2 = 1.48$ find numerical apperture.

Soln (a) $NA = \sqrt{2.25 - 2.22}$

$= \sqrt{0.03}$

$= \frac{\sqrt{3}}{10} = 1.714 = \boxed{0.1714}$

(b) $NA = \sqrt{2.25 - 2.19}$

$= \sqrt{0.06}$

$= \frac{\sqrt{6}}{10} = \frac{2.449}{10} = \boxed{0.2449}$

Q-15 Againt input power of 120 μW in a 8 km fibre the output is 3 μW. What is fibre loss in dB/km.

Soln $\alpha = \frac{10}{L} \log \frac{P_i}{P_0} \Rightarrow \alpha = \frac{10}{8} \log 40 \Rightarrow \frac{10 \times 1.6}{8}$

$\boxed{2\ dB}$

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Q.16 A 5 mW laser beam passes through a 26 km fiber of loss 0.2 dB/km. Cal. the power at output end.

Solⁿ

$$\alpha = \frac{10}{L} \log \frac{P_i}{P_o}$$

$$0.2 = \frac{10}{26} \log \frac{5}{P_o}$$

$$\frac{0.2 \times 13}{5} = \log \frac{5}{P_o}$$

$$\frac{2.6}{5} - \log 5 = -\log P_o$$

$$\log P_o = \log 5 - \frac{2.6}{5}$$

$$= 0.69 - 0.52$$

$$\log P_o = 0.17$$

$$P_o = e^{0.17}$$

$$[P_o = 1.18\ mW] \text{ Ans}$$

Q.17 The power of a 2 mW laser beam decrease to 10 μW after traversing through 25 km of single mode fiber. Cal. attenuation.

Solⁿ

$$\alpha = \frac{10}{25} \log \frac{2 \times 10^{-3}}{10 \times 10^{-6}}$$

$$\alpha = \frac{2}{5} \log 200$$

$$\alpha = \frac{2 \times 2.3}{5} = \frac{4.6}{5} = \boxed{0.92} \frac{dB}{km} \text{ Ans}$$

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