

1) A laser light emit light of 650nm. Calculate the frequency of the emitted light.

Soln:

$$\lambda = 650\text{nm}$$

$$f = \frac{c}{\lambda}$$

$$f = \frac{3 \times 10^8}{650 \times 10^{-9}} = 461 \times 10^{12}$$

$f = 461 \text{ THz}$

$$\text{m} \rightarrow 10^{-3}$$

$$\mu \rightarrow 10^{-6}$$

$$\text{n} \rightarrow 10^{-9}$$

$$\text{p} \rightarrow 10^{-12}$$

$$\text{k} \rightarrow 10^3$$

$$\text{M} \rightarrow 10^6$$

$$\text{G} \rightarrow 10^9$$

$$\text{T} \rightarrow 10^{12}$$

2) A positive test charge of 4C experiences a force of 20N when placed in an electric field. What is the magnitude of electric field at that point?

Soln.

$$q = 4\text{C}$$

$$F = 20\text{N}$$

$$E = \frac{F}{q} = \frac{20}{4} = 5\text{N/C}$$

3) A charged particle with charge of 2C is moving with a velocity of 10m/s perpendicular to a magnetic field of strength 0.5T . Calculate the force acting on the charged particle.

Soln.

$$q = 2\text{C}$$

$$v = 10\text{m/s}$$

$$B = 0.5\text{T}$$

$$F = qVB \sin \theta$$

$$\theta = 90^\circ$$

$$F = 2 \times 10 \times 0.5 \sin 90^\circ$$

$$F = 10 \text{ N}$$

4) Speed of the light in a medium is $2.5 \times 10^8 \text{ m/s}$. Calculate the Refractive index of the medium.

Soln $\therefore v = 2.5 \times 10^8 \text{ m/s}$

$$n = \frac{c}{v} = \frac{3 \times 10^8}{2.5 \times 10^8}$$

$$n = 1.2$$

5) A light ray is travelling from water to air. Calculate the critical angle of the light at the air water interface.

$$\theta = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

n_1 - water - denser medium

$n_2 \rightarrow$ air - less dense

$$n_1 = 1.33 \text{ (water)}$$

$$n_2 = 1 \text{ (air)}$$

$$\theta = \sin^{-1}\left(\frac{1}{1.33}\right)$$

$$\theta = 48.75^\circ$$

6) An optical fiber in air has a numerical aperture of 0.4. Calculate the acceptance angle.

Soln.

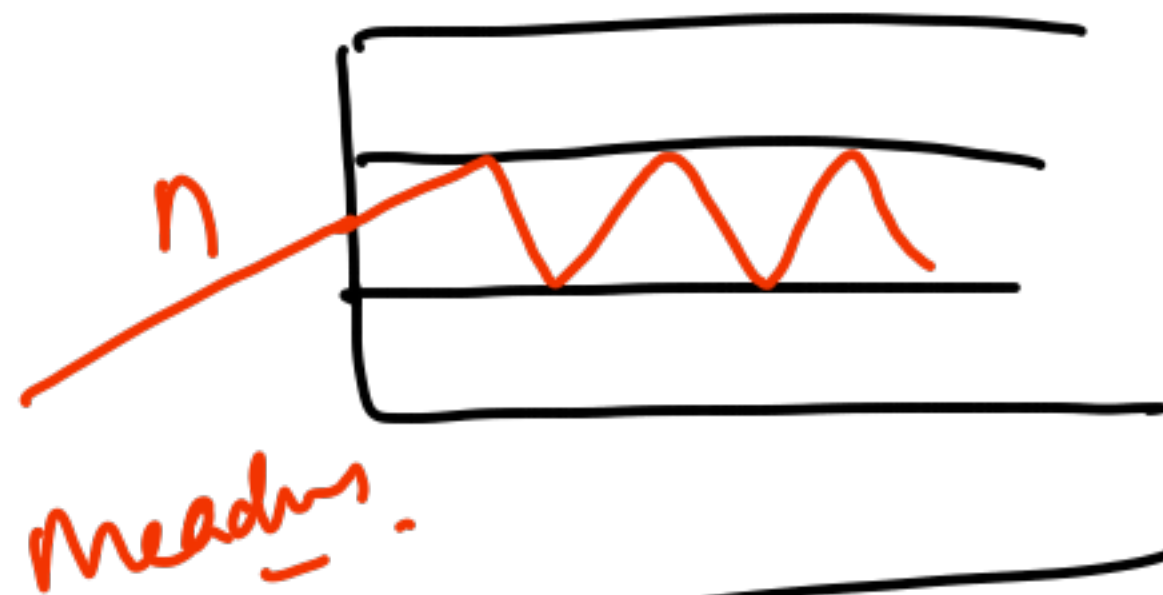
$$NA = n \sin \theta_a$$

$$NA = 0.4$$

$$n = 1 \quad (\text{air})$$

$$\theta_a = \sin^{-1} \left(\frac{NA}{n} \right)$$

$$\theta_a = \sin^{-1} \left(\frac{0.4}{1} \right)$$



$$\theta_a = 23.6^\circ$$

6) An optic fiber has a numerical aperture of 0.48 and the refractive index of the cladding is 1.45. Calculate the refractive index of the core.

Soln.

$$NA = 0.48$$

$$n_2 = 1.45$$

$$n_1 = ?$$

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

$$NA^2 = n_1^2 - n_2^2$$

$$n_1^2 = NA^2 + n_2^2$$

$$n_1 = \sqrt{NA^2 + n_2^2}$$

$$n_1 = \sqrt{(0.48)^2 + (1.45)^2}$$

$$n_1 = 1.53$$

7) An OFC system uses an optic fiber with a core refractive index of 1.5 and a cladding refractive index of 1.4. Calculate the acceptance angle of the fiber assuming that the light enters the fiber from air.

Soln

$$n_1 = 1.5$$

$$n_2 = 1.4$$

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

$$NA = \sqrt{(1.5)^2 - (1.4)^2}$$

$$NA = 0.54$$

$$NA = n \sin \theta_a$$

$$n = 1$$

$$\theta_a = \sin^{-1}\left(\frac{NA}{n}\right)$$

$$\theta_a = \sin^{-1}(0.54)$$

$$\theta_a = 32.68^\circ$$

Use of waveguide $\rightarrow$ direct EM

TE $\rightarrow$ E $\rightarrow$ $\perp$ to prop / H mode
TM $\rightarrow$ M $\rightarrow$ $\perp$ to prop / E mode
metal walls

TEM $\rightarrow$ E & M $\rightarrow$ $\perp$ to prop $\rightarrow$ band
2 medu.

dispersion $\rightarrow$ broadening of wave

Core $\rightarrow$ High refn

Cladding $\rightarrow$ Low Ref

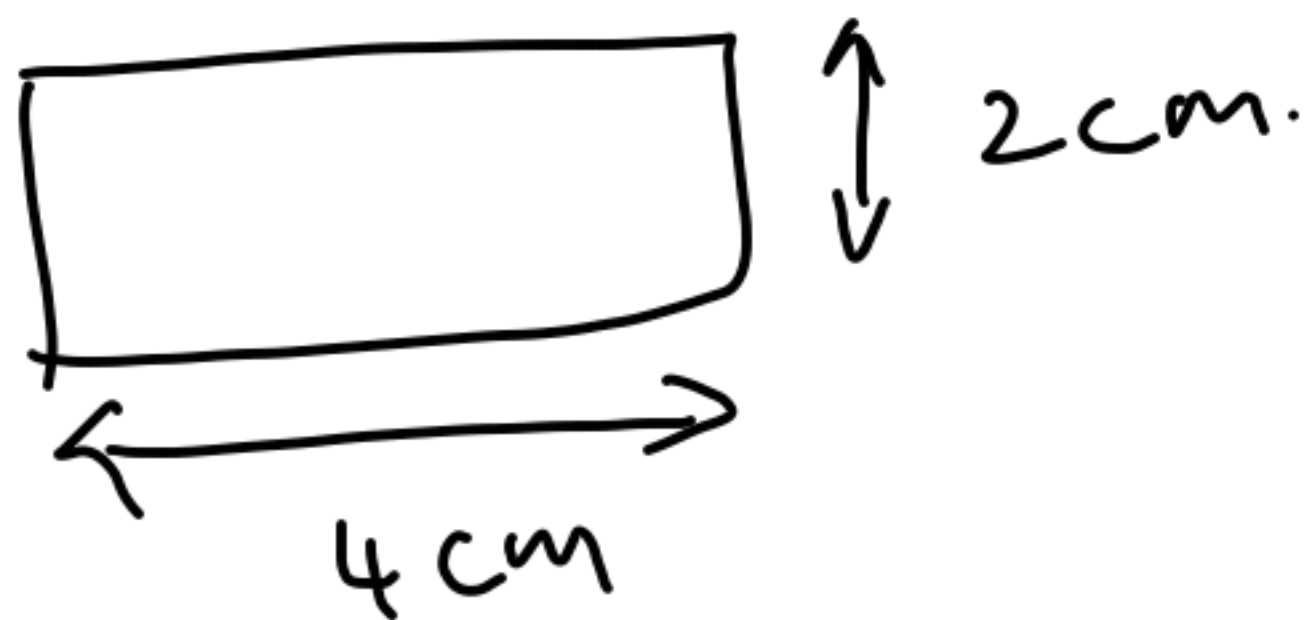
HM $\rightarrow$ TM, TE $\rightarrow$ H & M $\neq$ prop.

optiz fiber $\rightarrow$ Step index
 $\rightarrow$ Graded "

$\rightarrow$ single mode
 $\rightarrow$ multi mode
 $\rightarrow$ mode $\rightarrow$ Signal.

8) A rectangular waveguide has a width of 4cm and height of 2cm transmits TE_{11} mode. Calculate the cutoff frequency and the cutoff wavelength of the waveguide.

Soln:



Mode = TE_{11}

$m=1, n=1$

$$a = 4 \text{ cm} = 0.04 \text{ m}$$

$$b = 2 \text{ cm} = 0.02 \text{ m}$$

$$f_c = \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$f_c = \frac{3 \times 10^8}{2} \sqrt{\left(\frac{1}{0.04}\right)^2 + \left(\frac{1}{0.02}\right)^2}$$

$$f_c = 8.39 \text{ GHz}$$

Cutoff wavelength.

$$\lambda_c = \frac{c}{f_c}$$

$$= \frac{3 \times 10^8}{8.39 \times 10^9}$$

$$\lambda_c = 3.6 \text{ cm}$$

$$\lambda_c = 0.036 \text{ m}$$

9) A rectangular waveguide has a cutoff frequency of 8 GHz. The height of the waveguide is 0.03 m and it transmits TE_{11} mode. Calculate the width of the waveguide if the waveguide is filled with vacuum.

Soln:

$$f_c = 8 \text{ GHz}$$

$$TE_{11}$$

$$m = 1, n = 1$$

$$b = 0.03 \text{ m}$$

$$f_c = \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$\frac{2f_c}{c} = \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

Squaring both the sides

$$\frac{4f_c^2}{c^2} = \left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2$$

$$\left(\frac{m}{a}\right)^2 = \frac{4f_c^2}{c^2} - \left(\frac{n}{b}\right)^2$$

$$\frac{m^2}{a^2} = \frac{4f_c^2}{c^2} - \left(\frac{n}{b}\right)^2$$

$$a^2 = \frac{m^2}{\frac{4f_c^2}{c^2} - \left(\frac{n}{b}\right)^2}$$

taking sqm root on both the side.

$$a = \frac{m}{\sqrt{\frac{4f_c^2}{c^2} - \left(\frac{n}{b}\right)^2}}$$

$$a = \frac{1}{\sqrt{\frac{4 \times (8 \times 10^9)^2}{(3 \times 10^8)^2} - \left(\frac{1}{0.03}\right)^2}}$$

$$a = 2.4 \text{ cm}$$

$$a = 0.024 \text{ m}$$

Dominant mode $\rightarrow$ lowest cutoff freq. mode

Evanescent mode $\rightarrow$ below the cutoff freq.
 $\rightarrow$ lost

