

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

Soln.

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

$$\lambda = 650 \times 10^{-9} \text{ m}$$

$$f = ?$$

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

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

$$f = 461 \times 10^{12} \text{ Hz}$$

$$\underline{\underline{f = 461 \text{ THz}}}$$

2) A positive test charge of $q_0 = 4 \text{ C}$ experiences a force $F = 20 \text{ N}$ when placed in an electric field. What is the magnitude of the Electric field (E) at that point?

Soln.

$$E = \frac{F}{q_0}$$

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

3) A charged particle with charge $q = 2\text{C}$ is moving with a velocity $v = 10\text{m/s}$ perpendicular to a magnetic field of strength $B = 0.5\text{T}$. Calculate the force (F) acting on the charged particle.

Solution.

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

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

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

$$F = qvB \sin \theta$$

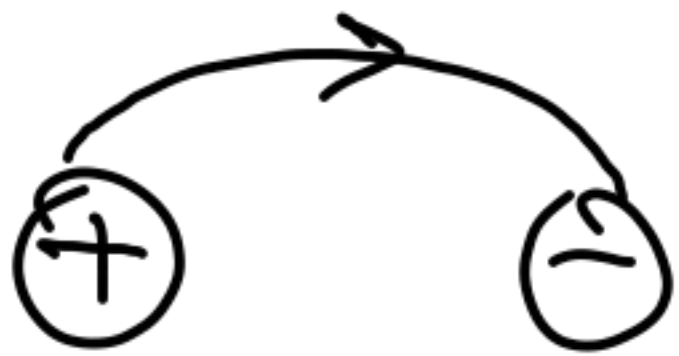
$$\theta = 90^\circ$$

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

$$F = 2 \times 10 \times 0.5 \times 1$$

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

Electric field



$$E = \frac{F}{q_0}$$

Magnetic field



$$F = qvB \sin \theta$$

→ Maxwell

→ Hertz:

→ Faraday law of Induction — $B \rightarrow E$

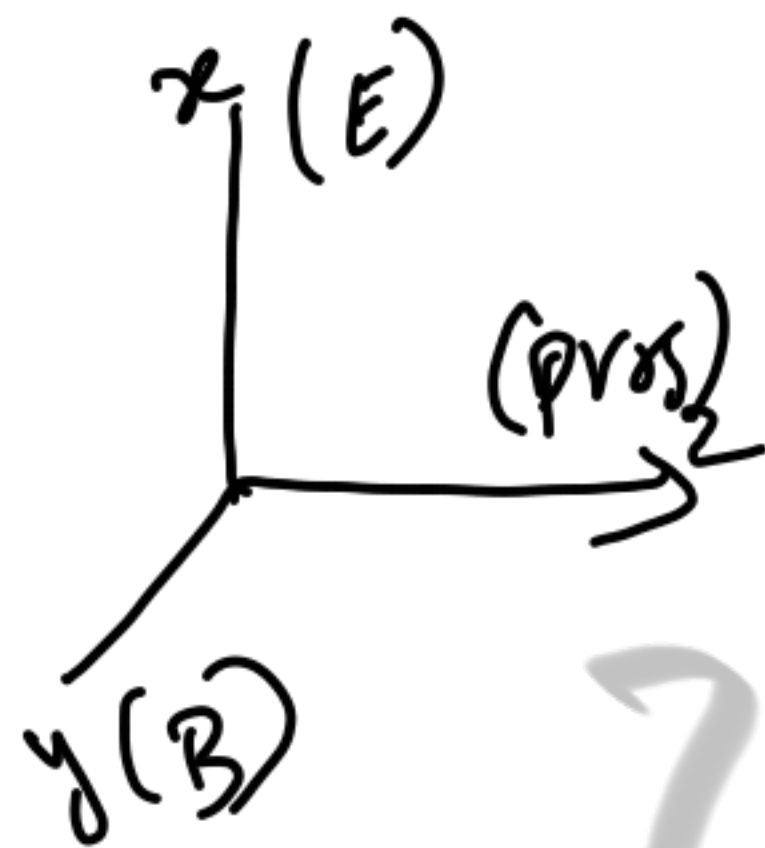
→ Ampere's - Circuit law $\rightarrow E - B$

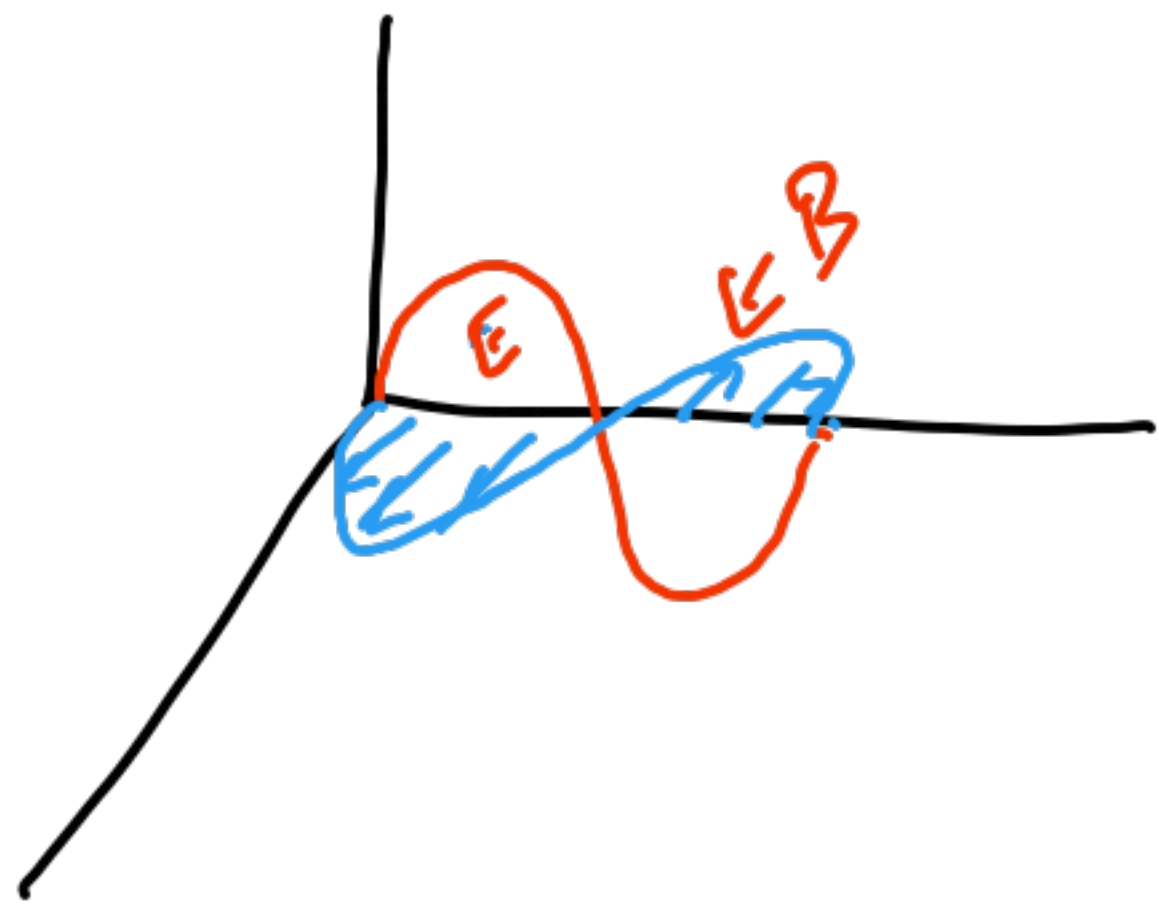
→ Right hand Rule $\rightarrow$ forefinger — E

$\rightarrow$ Middle finger (Curl) $\rightarrow B$

$\rightarrow$ Thumb $\rightarrow$ direction of prop.

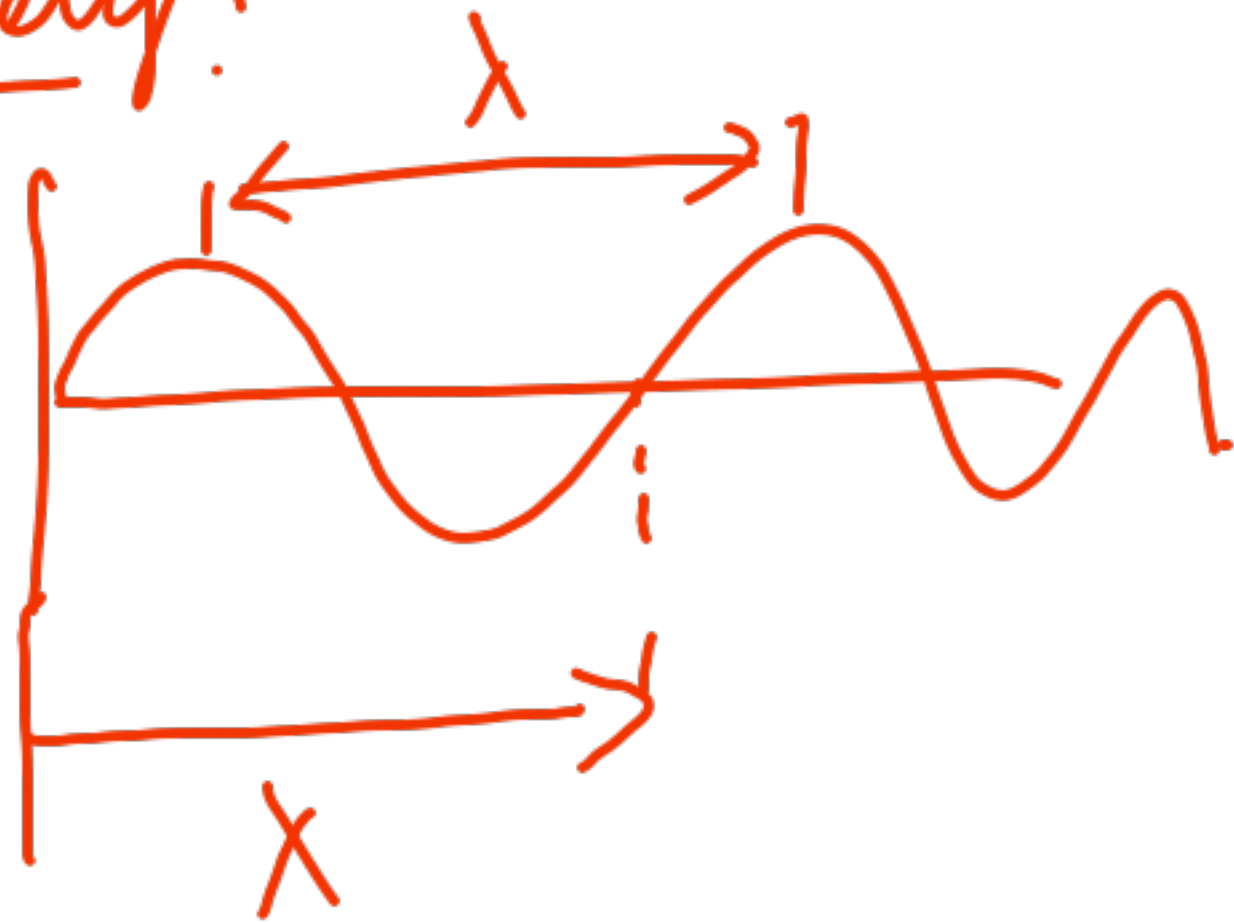
$E, B, \text{Propagation} \rightarrow \text{Perpendicular / Transvers}$





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

wavelength



Time period

Time taken for one cycle.

Frequency

No. of cycles per second.

EM Spectrum

Radio ✓

Microwave ✓

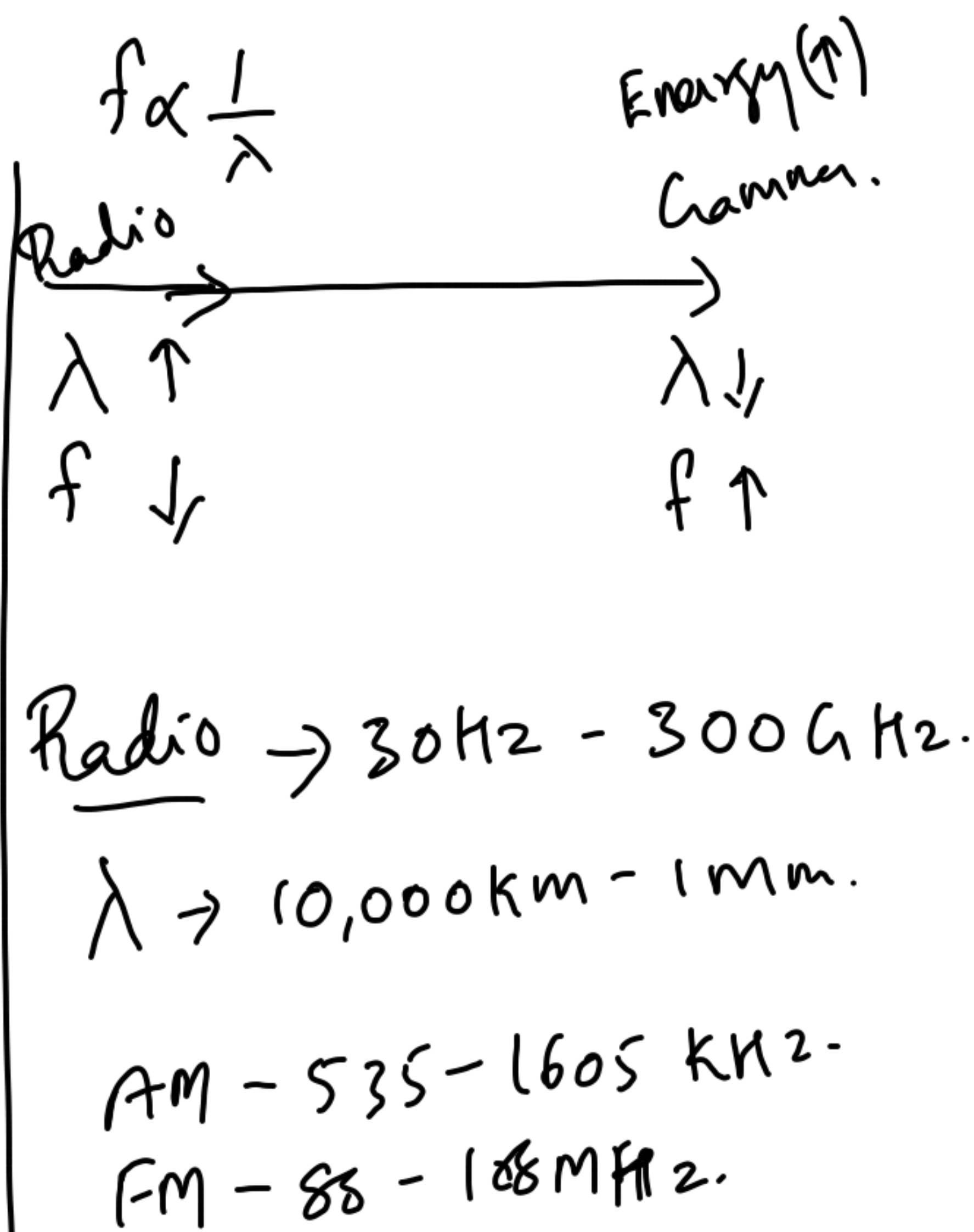
IR ✓

Visible ✓

UV

X-Ray

Gamma



Ex. low → deep Earth / deep sea.

↓
medium

↓
Extr. high → 5G, Advanc. RF Comm.
→ wifi, mobile . . .

→ Interference & Attenuation
is high.

→ MRI - Scans

Microwave - $300\text{MHz} - 300\text{GHz}$.

$\lambda - 1\text{m} - 1\text{mm}$.

→ Radar → Radar detecting and Ranging

→ Satellite

→ line of sight

→ narrow

IR →

$f \rightarrow 300\text{GHz} - 430\text{THz}$

$\lambda = 1\text{mm} - 700\text{nm}$.

near, mid, far | Thermal imaging.

Visible.

$f = 400 - 790\text{THz}$

$380 - 700\text{nm}$.

UV →

$f = 30\text{PHz} - 750\text{THz}$

$\lambda = 10\text{nm} - 400\text{nm}$

UV-A, UV-B, UV-C

→ medical.

X-Ray - 30 pHz - 30 EHz.

$\lambda = 10 \text{ p} - 10 \text{ nm}.$

→ medical imaging

Gamma → 30 EHz. >

$\lambda < 10 \text{ p} >.$

→ medical imaging.

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

Soln.

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

$$n = 1.2$$

5) A light ray is travelling from water to air. Calculate the Critical angle for the light ray at the air-water interface.

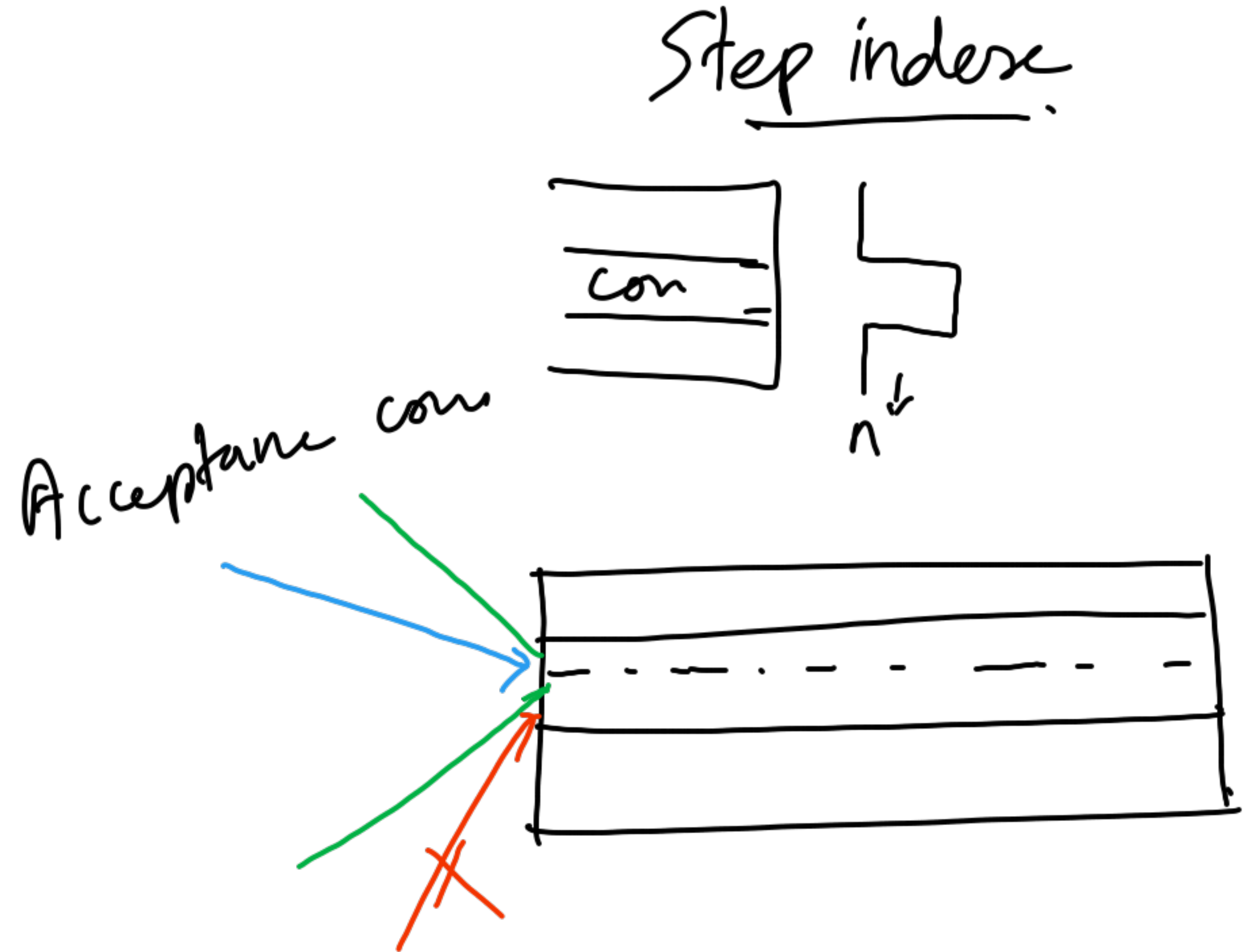
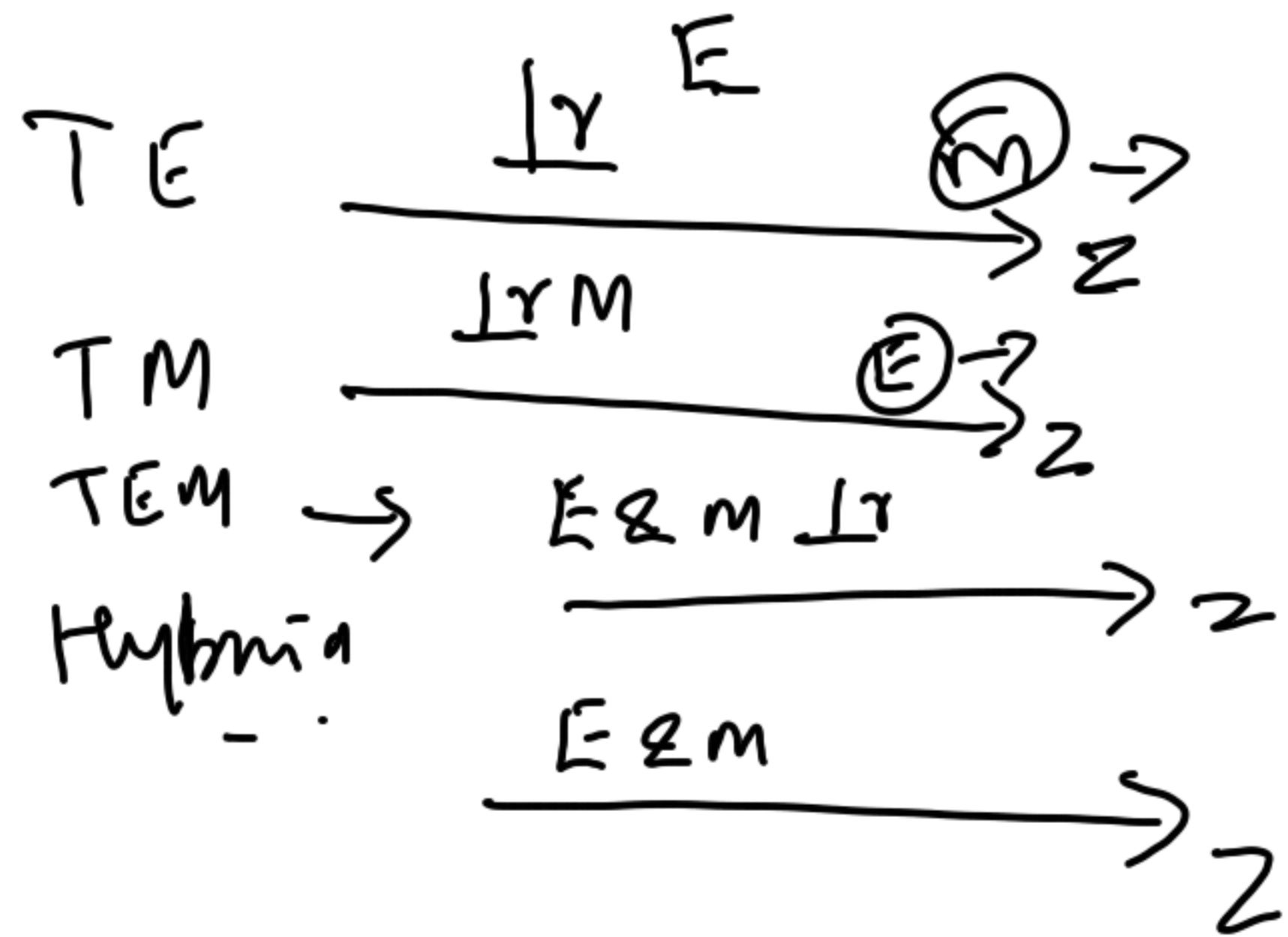
Soln.

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

$$n_2 = 1$$

$$n_1 = 1.33$$

$$\theta_c = \sin^{-1} \left(\frac{1}{1.33} \right) = 48.75^\circ$$



6) An optic fiber in air has a Numerical Aperture of 0.4.
Calculate the acceptance angle.

Soln..

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

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

$$\theta_a = 23.58^\circ$$

7). An optic fiber has a NA of 0.48 and the refractive index of the cladding is 1.45.
Calculate the refractive index of the core.

Soln

$$NA = 0.48$$

$$n_2 = 1.45$$

$$n_1 = ? \rightarrow \text{Refractive index of core}$$

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

Squaring both sides.

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

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

$$\rightarrow \text{Taking Square root.}$$

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

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

$$n_1 = 1.53$$

8) 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:

$$n_0 = 1, \quad n_1 = 1.5, \quad n_2 = 1.4$$

$$n_0 \sin \theta_a = NA$$

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

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

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

$$NA = 0.54$$

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

$$\theta_a = 32.68^\circ$$

9) A rectangular waveguide has a width of 4cm and height of 2cm transmits TE_{11} mode calculate the.

Cutoff frequency and Cutoff wavelength of the waveguide.

Soln.

$$a = 4\text{cm} = 4 \times 10^{-2}\text{m}$$
$$b = 2\text{cm} = 2 \times 10^{-2}\text{m}$$

$$TE_{11} \approx TE_{mn}$$

$$m = 1$$

$$n = 1$$

$$3 \times 10^9 / 3 \times 10^6$$

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

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

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

To find cutoff wavelength

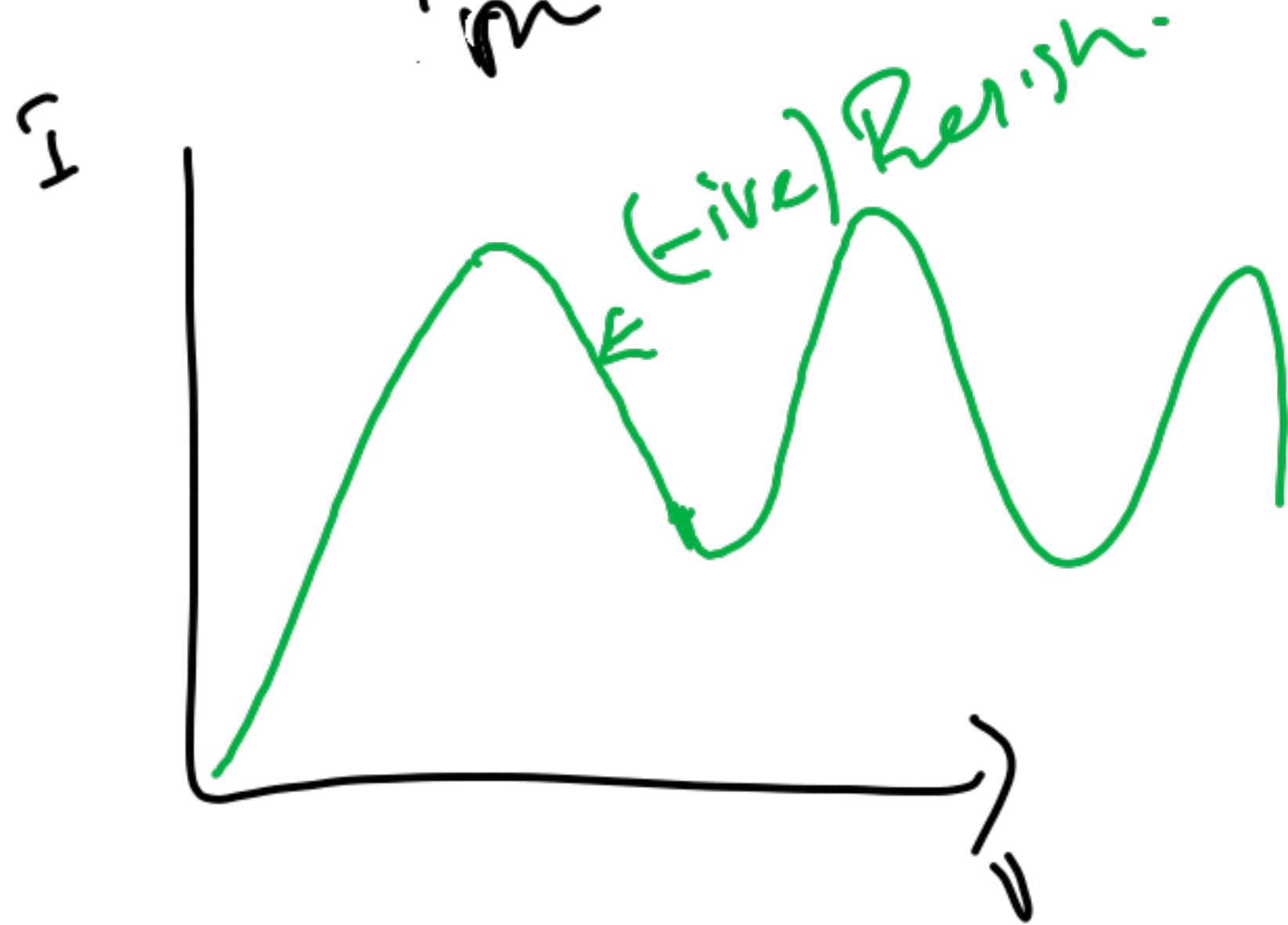
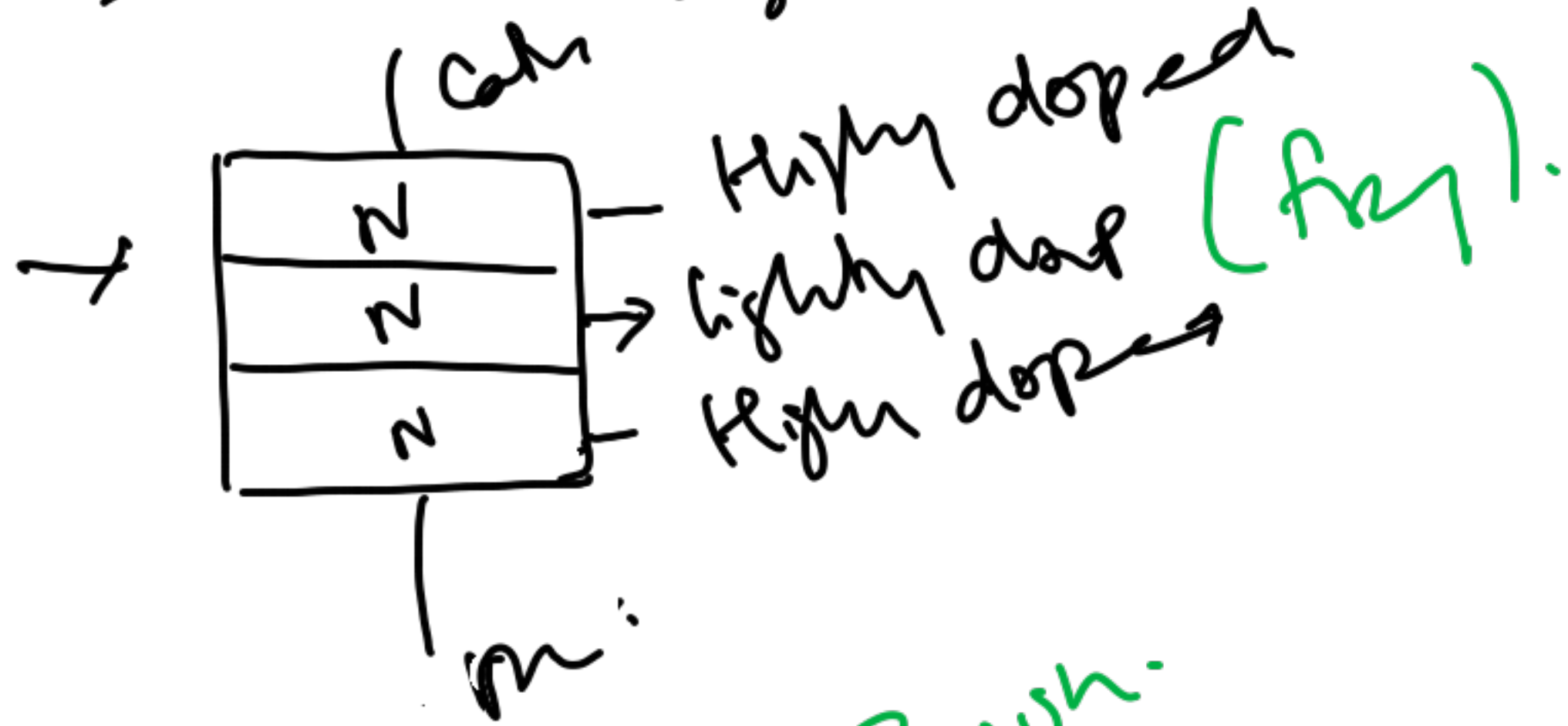
$$\lambda_c = \frac{c}{f_c}$$

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

$$\lambda_c = 35.8 \text{ mm}$$

Crown diode

→ Microwave signal



Klystron

→ Electron gun

→ Buncher cavity

→ Drift Space

→ Catcher Cath.

→ Collectn.

frequency meter

→ Freq through waveguide.

Slotted Section

→ Stranding wave ratio.

→ wavelength, ---

Attenuator:

Reduces the power level.

Slide screw tuner

→ Match the impedance of
Tx line

Circulator



E & H bend

Change in direction.

Isolator

→

unidirect.

(arrest the Reflected
Signal)

Movable short.

Adjust Reflnt.

Directional Coupler

$P_1 \rightarrow i/p$, $P_2 \rightarrow o/p$, $P_3 \rightarrow \text{Isolated}$
 $P_4 \rightarrow \text{coupled}$

Magic Tee

P_1 & $P_2 \rightarrow \text{Co-linear}$.

$P_3 \rightarrow \text{Sum port}$.

$P_4 \rightarrow \text{Difference port}$.

i/p P_1 & P_2 .

$P_3 \rightarrow \text{Sum}$

$P_4 \rightarrow \text{diff}$

i/p at P_3 .

$P_4 \rightarrow \text{No Signal}$.

$P_1 \rightarrow 1/2$ (in phase)
 $P_2 \rightarrow 1/2$

if at P_4 :

$P_3 \rightarrow$ No signal

$P_1 \rightarrow I_{12}$
 $P_2 \rightarrow I_{12}$ } 180° phase shift

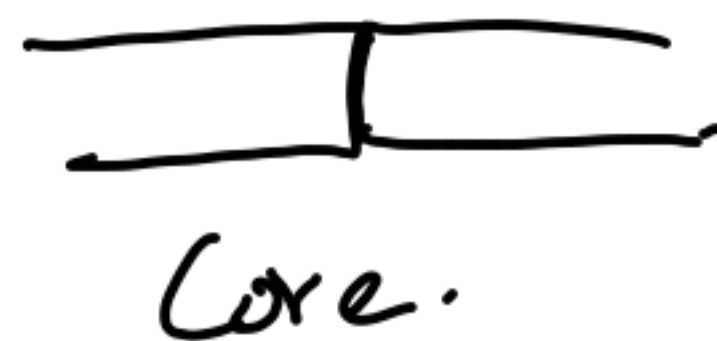
Matched Terminators
absorbs signal,
Prevent Reflection.

Optics

Connectors $\rightarrow$ Ferrule.
 $\rightarrow$ Duplex connector
 $T_x \& R_x$



Couplers $\rightarrow$ Core interaction.
 $\rightarrow$ Surface interaction.



Surface



Splitter



Combine

