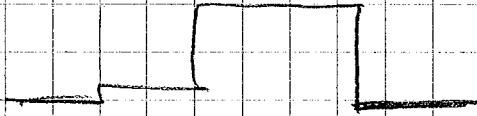
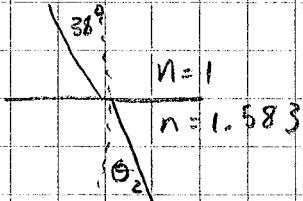


Waves

①



②



$$(a) \frac{\sin \theta_2}{\sin \theta_1} = \frac{n_1}{n_2}$$

$$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1) \sin(38^\circ)}{1.583}$$

$$\theta_2 = \underline{23^\circ}$$

$$(b) \frac{n_1}{n_2} = \frac{v_2}{v_1}$$

$$v_2 = \frac{n_1 v_1}{n_2} = \frac{(1)(3 \times 10^8 \text{ ms}^{-1})}{1.583} = \underline{1.9 \times 10^8 \text{ ms}^{-1}}$$

(c) frequency of the light remains the same
in air

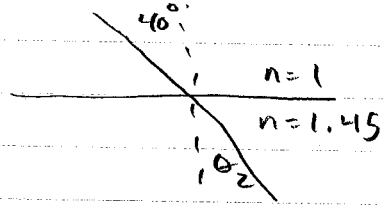
$$v = f\lambda$$

$$f = \frac{v}{\lambda} = \frac{3 \times 10^8 \text{ ms}^{-1}}{6.8 \times 10^{-7} \text{ m}} = 4.4 \times 10^{14} \text{ Hz}$$

so in glass

$$\lambda = \frac{v}{f} = \frac{1.9 \times 10^8 \text{ ms}^{-1}}{4.4 \times 10^{14} \text{ Hz}} = \underline{4.3 \times 10^{-7} \text{ m}}$$

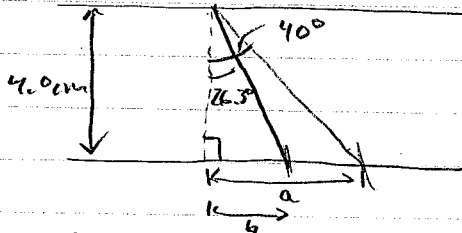
3



$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1}$$

$$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1) \sin 40^\circ}{1.45}$$

$$\theta_2 = 26.3^\circ$$



unrefracted distance = a

$$\tan 40^\circ = \frac{a}{4 \text{ cm}}$$

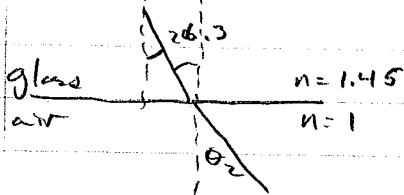
$$a = 3.356 \text{ cm}$$

refracted distance = b

$$\tan 26.3 = \frac{b}{4 \text{ cm}}$$

$$b = 1.977 \text{ cm}$$

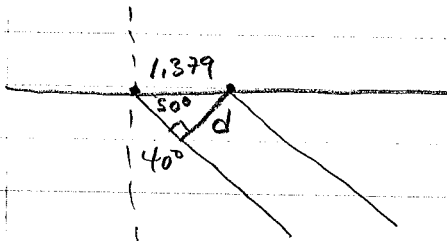
∴ difference is $3.356 - 1.977 \text{ cm} = 1.379 \text{ cm}$.



$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1}$$

$$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{1.45 \sin (26.3^\circ)}{1}$$

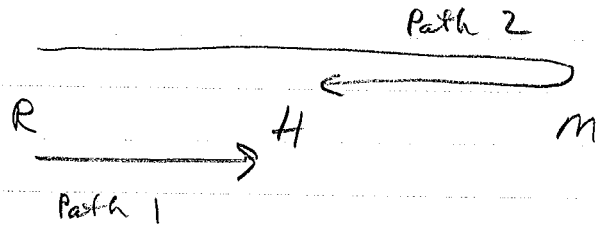
$$\theta = 40^\circ$$



$$\sin 50^\circ = \frac{d}{1.379 \text{ cm}}$$

$$d = 1.06 \text{ cm}$$

④



- the reception is poor so there must be destructive interference at H
- therefore the path difference must be $\frac{\lambda}{2}$

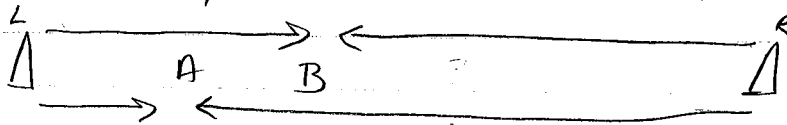
$$(RH + HM + HM) - (RH) = \frac{\lambda}{2}$$

$$2HM = \frac{\lambda}{2}$$

$$HM = \frac{\lambda}{4} = \frac{1600\text{m}}{4} = \underline{400\text{m}}$$

⑤

- A - constructive; path difference to A must be λ
- B - destructive; path difference to B must be $\frac{\lambda}{2}$



$$\lambda = AR - LA = AB + BR - LA$$

$$\frac{\lambda}{2} = BR - LB = BR - (LA + AB) = BR - LA - AB$$

$$BR - LA = \lambda - AB$$

$$BR - LA = \frac{\lambda}{2} + AB$$

$$\lambda - AB = \frac{\lambda}{2} + AB$$

$$\frac{\lambda}{2} = 2AB$$

$$AB = \frac{\lambda}{4}$$

$$v = f\lambda$$

$$\lambda = \frac{v}{f} = \frac{3 \times 10^8 \text{ms}^{-1}}{90 \times 10^6 \text{Hz}} = 3.33\text{m}$$

$$AB = \frac{\lambda}{4} = \frac{3.33\text{m}}{4} = \underline{0.833\text{m}}$$

- ⑥ (a) unpolarized light - the intensity will always be reduced by one-half
 (b) polarized light - only light that is parallel to the plane of polarization will be transmitted.
 (c) partially polarized light - only light that is parallel to the plane of polarization will be transmitted; In this case, there is always light parallel as the original light is not completely polarized to one plane.

⑦ The fraction of intensity transmitted is proportional to the square of the cosine of the angle.

$$I = I_0 \cos^2 \theta$$

⑧
$$I = I_0 \cos^2 \theta$$

$$\frac{I}{I_0} = \cos^2(25^\circ) = \underline{0.82}$$

⑨ unpolarized light is at all angles (0-360°)

Therefore, since a polarizer only allows light parallel to the transmission axis to pass it would be reasonable to take an average.

The average value of $\cos^2 \theta$ from 0-360° is $\frac{1}{2}$

$$\therefore I = \frac{I_0}{2}$$

⑩ Light reflecting off the surface of the water causes a "glare."

This reflected light is polarized parallel to the surface of the water (ie) horizontally.

Polarized sunglasses have a vertical transmission axis.

Since the polarized sunglasses have an axis of transmission at 90° to the polarized reflected light, the reflected light is blocked.

Therefore, the "glare" is eliminated allowing the fisherman to better see the fish.