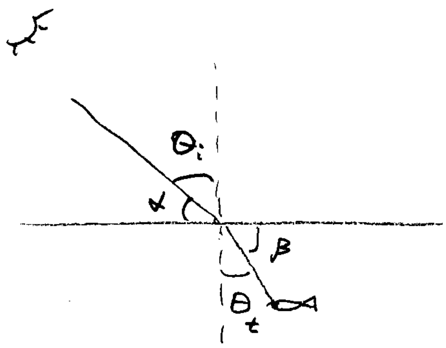
PHYS 471 Optics

Midterm examination

Solutions

$\boxed{1}$



$\theta_t = 90° - \beta = 30°$

$$n_{air} \sin \theta_i = n_{water} \sin \theta_t$$

$n_{air} = 1$, $n_{water} = 4/3$, $\sin\theta_t = 1/2$

$$\theta_i = \arc\sin\left(n \sin\left(\tfrac{\pi}{2} - \alpha\right)\right)$$

$$= \arc\sin 2/3 = 41.8°$$

$$\alpha = \tfrac{\pi}{2} - \theta_i = 90° - \arc\sin 2/3 = 48.2°$$

$\boxed{2}$

$$r_{TE} = \frac{\cos\theta_i - n\cos\theta_t}{\cos\theta_i + n\cos\theta_t} = -0.214$$

$$r_{TM} = \frac{\cos\theta_t - n\cos\theta_i}{\cos\theta_t + n\cos\theta_i} = -0.067$$

$$R_{TE} = r_{TE}^2 = 0.046$$

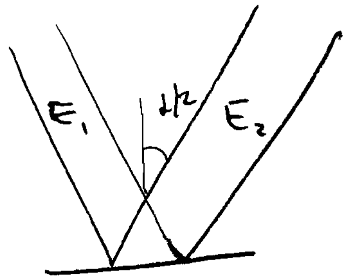
$$R_{TM} = r_{TM}^2 = 0.004$$

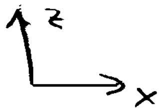
Solar light contains equal amount of both polarizations.
If incident power is I_0, the reflected power is

$$R_{TE}\frac{I_0}{2} + R_{TM}\frac{I_0}{2} = I_0\frac{R_{TE} + R_{TM}}{2}$$

Answer: $\dfrac{R_{TE} + R_{TM}}{2} = 0.025$

$\boxed{3}$ a)





$$E_1 = E_0\, e^{-ik_z z + ik_x x - i\omega t}$$

$$E_2 = E_0\, e^{-ik_z z + ik_x x - i\omega t}$$

$$E_1 + E_2 = E_0\, e^{-ik_z z - i\omega t}\left(e^{ik_x x} + e^{-ik_x x}\right)$$

$$= 2E_0\, e^{-ik_z z - i\omega t} \cos(k_x x)$$

Intensity $\quad I = |E_1 + E_2|^2 = (E_1 + E_2)(E_1 + E_2)^* = 4E_0^2 \cos^2(k_x x)$

$\cos^2 k_x x = 1$ if $k_x x = 0, \pi, 2\pi \ldots$

or $\quad x = 0, \frac{\pi}{k_x}, \frac{2\pi}{k_x}, \ldots$

Fringe period $\quad \frac{\pi}{k_x} = \frac{\pi}{k \sin \alpha/2} = \frac{\lambda}{2 \sin \alpha/2} \approx \frac{\lambda}{\alpha} = 36.2\,\mu m$

b) "Perfectly stable" $\Rightarrow \tau_c = \infty$

$\boxed{4}$

$$\left.\begin{array}{l} \frac{1}{s} - \frac{1}{s'} = \frac{1}{f} \\ s' = sM = 2\,cm \end{array}\right\} \Rightarrow f = -6\,cm \quad \text{diverging (concave) lens}$$