33#18

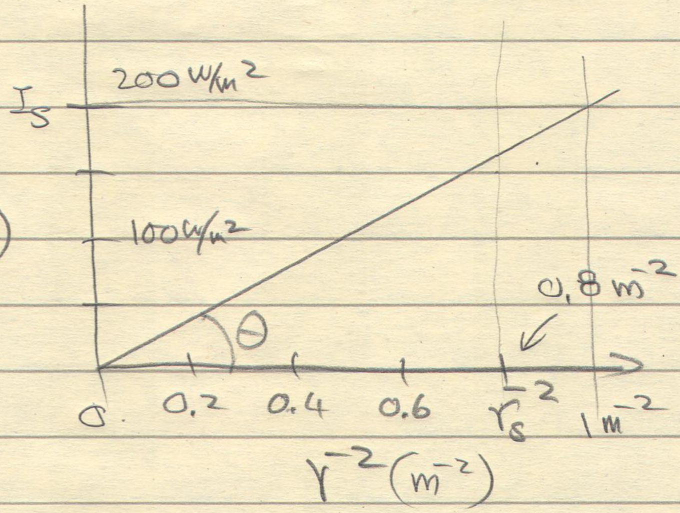
$$I = \frac{P}{\text{Area}}$$

For isotropic radial (W/m²)

Area $= 4\pi r^2$

$$I_s = \frac{P}{4\pi r^2}$$

$$I_s = \frac{P}{4\pi}\left(r^{-2}\right)$$

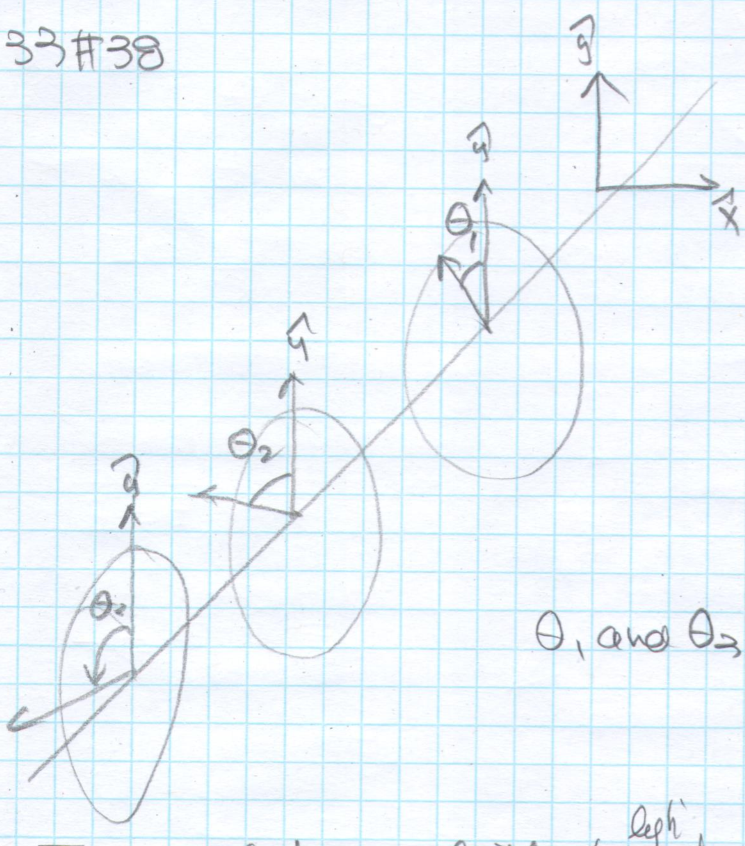


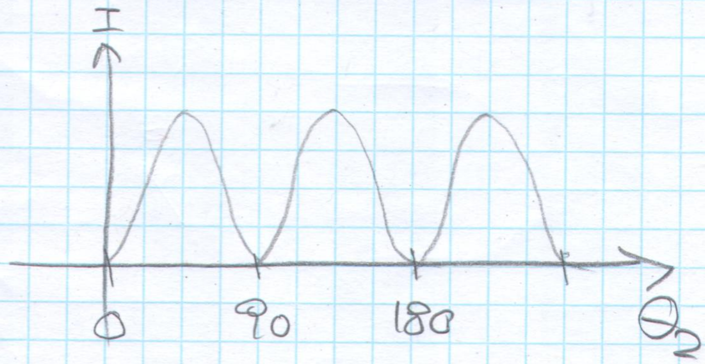
slope of I_s vs. r^{-2} is $\frac{P}{4\pi}$

$$P = (\text{slope})\,4\pi = (\tan\theta)\,4\pi = \left(\frac{200\ \text{W/m}^2}{1\ \text{m}^{-2}}\right)4\pi$$

$$= \underline{\underline{800\pi \text{ watt}}}$$

33 #38

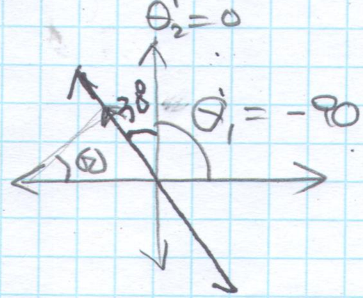




θ_1 and θ_3 fixed.

For non polarized light, the light intensity that passes through the filter is $\frac{1}{2}$, since it only allow one of the two $\vec{E}(t)$ field to pass through.

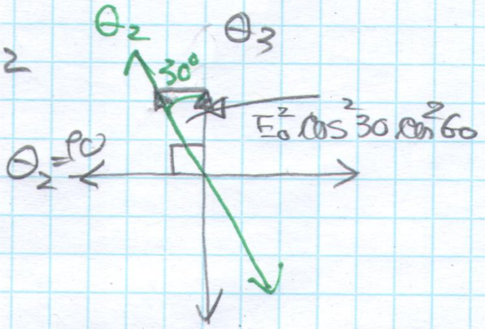
From the I vs θ_2 diagram it is clear that $\theta_2 = 0$. It's polarization axis is $\perp$ to filter θ_1. $\therefore$ θ_1 must be Horizontally polarized



By exam. the min at 90°, θ_2 must be $\perp$ to that of polarization axis of θ_3.

$\theta_3 = 0$.

Now if θ_2 is at $\underline{30^\circ}$ it will allow a fraction of E from θ_1 projected to θ_2 $= \cos 60^\circ$ and



allow a fraction of E from θ_2 projected to θ_3 $= \cos 30^\circ$

Since $I = E^2$.

$$I = \frac{I_0}{2}\cos^2 60 \cos 30^\circ$$

$$\frac{I}{I_0} = \frac{1}{2}\cos^2 60 \cos^2 30 = 9.4\%$$

33 #43 partially polarized light: - polarized light + non polarized light

3

For non polarized light, a polarizer will transmit $\frac{1}{2}$ intensity at all angle ie $\frac{I_u}{2}$

For polarized light, a polarizer will transmit I_p when the electric field vector of the light matches that of the polarizer axis of the filter ie I_p and will not pass the I_p when the axis of the filter is $\perp$ to I_p

$$\text{Max transmission} = \frac{I_u}{2} + I_p$$

$$\text{minimum transmission} = \frac{I_u}{2}$$

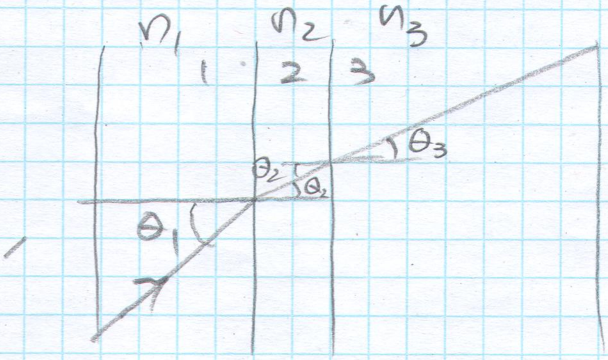
the ratio is 5 ie $\dfrac{\left(\frac{I_u}{2}\right) + I_p}{\left(\frac{I_u}{2}\right)} = 5$

$$\frac{I_u}{2} + I_p = 5\frac{I_u}{2} \Rightarrow I_p = 4\frac{I_u}{2} = \underline{\underline{2I_u}}$$

what fraction of $\frac{I_p}{I_u + I_p}$?

$$R = \frac{2I_u}{I_u + 2I_u} = \frac{2}{3} \;//$$

33-50 $\theta_1 = 40°$



a) $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 \sin\theta_2 = n_3 \sin\theta_3$

$n_1 \sin\theta_1 = n_3 \sin\theta_3$

$n_1 = \dfrac{n_3 \sin\theta_3}{\sin\theta_1}$

if $\theta_3 = \theta_1 \Rightarrow n_1 = n_3$ $\therefore$ $\theta_1 = \theta_3 = 40$, $n_1 = \underline{\underline{1.6}}$ given

b) n_2 ?

$n_2 \sin\theta_2 = n_3 \sin\theta_3$ two unknown variables n_2 and θ_2.

insufficient info.

c) $\theta_1 = 70$. $n_3 = 2.4$ Find θ_3

$n_1 \sin\theta_1 = n_3 \sin\theta_3$

$\sin\theta_3 = \dfrac{n_1}{n_3} \sin\theta_1$

$\theta_3 = \sin^{-1}\left(\dfrac{n_1}{n_3}\right)\sin\theta_1$

$= \sin^{-1}\left(\dfrac{1.6}{2.4}\right)\sin 70$

$= \underline{38.8}°$

33 #52

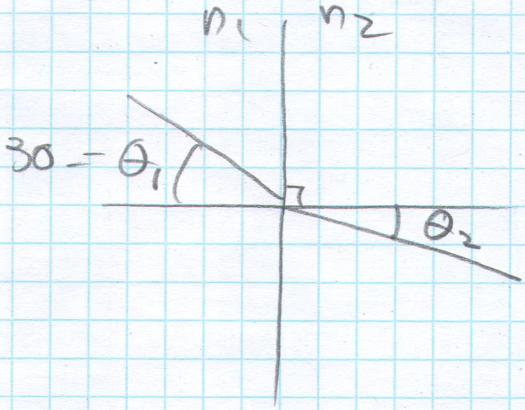
(a) $n_1 \sin\theta_1 = n_2 \sin\theta_2$

range of θ_2 and n_2

$(1.3, 40°), (1.9, 26°)$

if $n_1 = n_2$, $\theta_1 = \theta_2 = 30°$

$\therefore n_1 = 1.7$



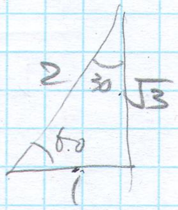
(b) $\theta_1 = 60$, $n_2 = 2.4$

θ_2 ?

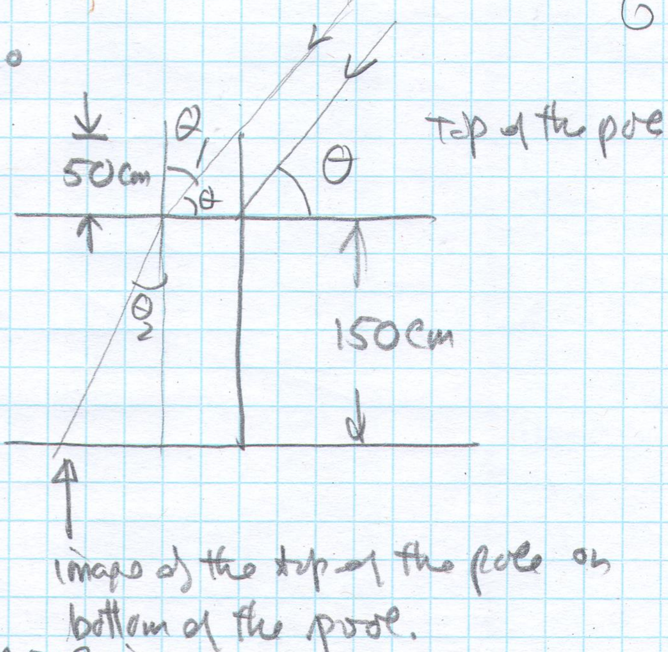
$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right) = \sin^{-1}\left[\left(\frac{1.7}{2.4}\right)\sin 60\right]$

$= 37.8°$



33 #55 $\quad \theta = 55^\circ \Rightarrow \theta_1 = 90^\circ - 55^\circ = 35^\circ$



$n_{air} \sin 35 = n_w \sin\theta_2$

$\theta_2 = \sin^{-1}\left[\left(\frac{n_{air}}{n_w}\right)\sin 35\right]$

$= \sin^{-1}\left(\frac{1}{1.33}\right) 0.574$

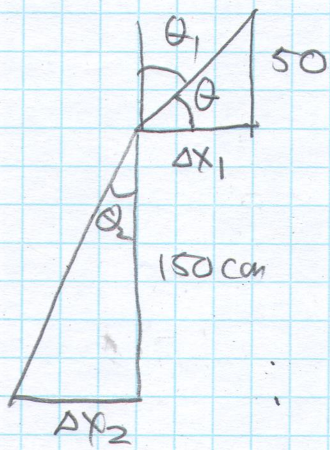
$= \underline{25.5^\circ}$

The length of the shadow for the 2m pole is:

$\Delta X = \Delta X_1 + \Delta X_2$

$= \frac{50}{\tan\theta} + (150)(\tan\theta_2)$

$= \frac{50}{\tan 55} + (150)(\tan 25.5)$ //



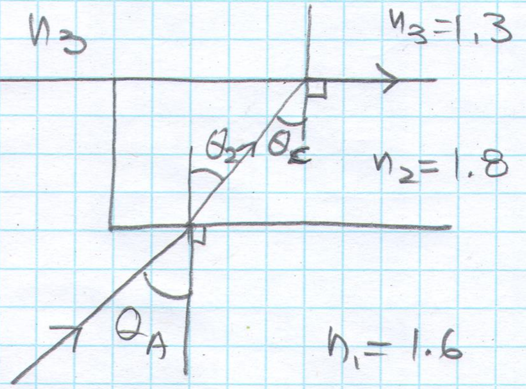
$\tan\theta = \frac{50}{\Delta X_1}$

$\tan\theta_2 = \frac{\Delta X_2}{150}$

7

33 #60 $\theta_A = ?$

$\theta_2 = \theta_c$ for interface of n_2 & n_3



For critical $\theta_3 = 90$

$n_2 \sin\theta_c = n_3 \sin 90$, where $\sin 90 \to 1$

$\theta_c = \sin^{-1}\left(\frac{n_3}{n_2}\right) = \sin^{-1}\left(\frac{1.3}{1.8}\right) = 46.2^\circ$

use snell's law to find θ_A

$n_1 \sin\theta_A = n_2 \sin\theta_2 = n_2 \sin\theta_c$

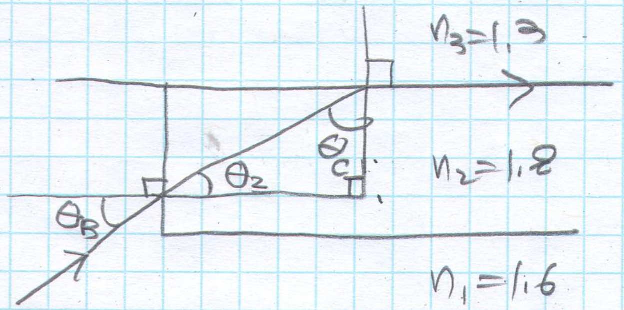
(a) $\theta_A = \sin^{-1}\left(\frac{n_2}{n_1}\sin\theta_c\right) = \sin^{-1}\left(\frac{1.8}{1.6}\right)\left(\frac{1.3}{1.8}\right) = \underline{\underline{54.3^\circ}}$

(b) If θ_A decrease, θ_2 will decrease and $\theta_2 < \theta_c$, $\Rightarrow$ total internal reflection.

For Ray (B)

(c) $\theta_2 = 90 - \theta_c$

$= 43.8$



$n_1 \sin\theta_B = n_2 \sin\theta_2$

$\theta_B = \sin^{-1}\left(\frac{n_2}{n_1}\sin\theta_2\right)$

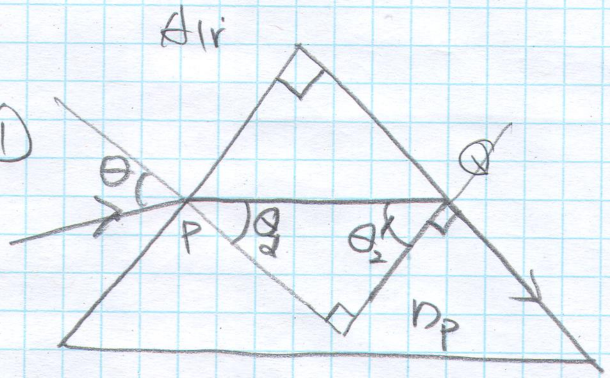
$= \sin^{-1}\left(\frac{1.8}{1.6}\sin(43.8)\right)$ //

$= 51.1^\circ$ //

(d) If θ_B decrease θ_2 decrease and incident angle to $n_3 > \theta_c$

$\Rightarrow$ total internal reflection

33 #63 Find $n_{prism} = f(\theta)$



(a) Consider P

$$\boxed{n_{Air}\sin\theta_A = n_p \sin\theta_2} \quad — (1)$$

and $\theta_2 + \theta_2' = 90$

$\theta_2' = 90 - \theta_2$

At Q

$$n_p \sin(90-\theta_2) = n_A \underbrace{\sin 90}_{1} = n_A$$

$$n_p(\underbrace{\sin 90}_{1} \cos\theta_2 - \underbrace{\cos 90}_{0} \sin\theta_2) = n_A$$

$$\boxed{n_p \cos\theta_2 = n_A} \quad — (2)$$

(b) $\sin\theta_2^2 + \cos\theta_2^2 = 1$

From (1) $\left(\frac{n_A \sin\theta_A}{n_p}\right)^2 = \sin^2\theta_2$

From (2) $\left(\frac{n_A}{n_p}\right)^2 = \cos^2\theta_2$

$$\frac{n_A^2 \sin^2\theta_A}{n_p^2} + \frac{n_A^2}{n_p^2} = 1$$

$$(\sin^2\theta_A + 1) = n_p^2$$

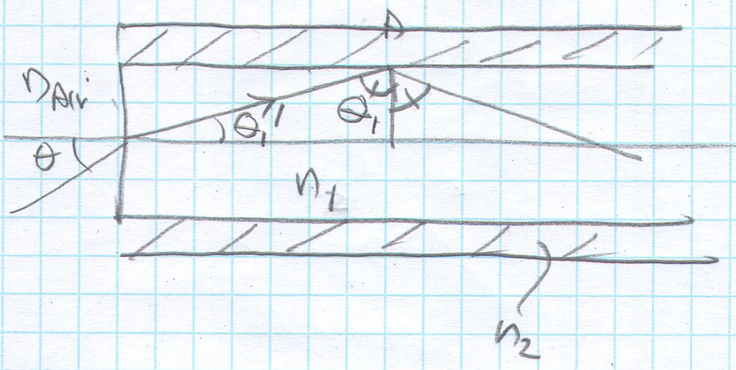
$n_p = \sqrt{(\sin^2\theta + 1)}$ where θ_A is just θ.

Let $\theta = 90$. $n_p = \sqrt{1+1} = \sqrt{2} = 1.414$

(c) Increase θ increases slightly, θ_2 will increase and $\theta_2' < \theta_c \Rightarrow$ light will emerge at Q

(d) If θ decrease slightly, θ_2 will decrease and $\theta_2' > \theta_c \Rightarrow$ total internal reflection

33-65 $n_1 = 1.58$
$n_2 = 1.53$



Find max angle θ that allows Total internal reflect

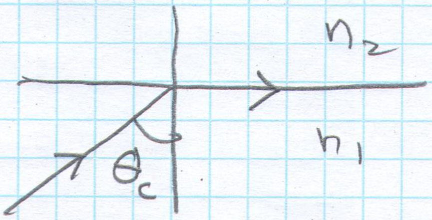
Find θ_c at interface n_1 & n_2

$$n_1 \sin\theta_c = n_2 \sin 90$$

$$\theta_c = \sin^{-1}\left(\frac{n_2 \sin 90}{n_1}\right)$$

$$= \sin^{-1}\left(\frac{1.53}{1.58}\right)$$

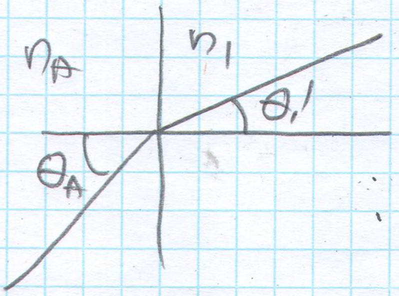
$$= \underline{75.5^\circ}$$



θ_1 must be $\geq 75.5^\circ$ for total internal reflection

θ_1 & θ_1' are related. $\theta_1' = 90 - \theta_1 = 90^\circ - 75.5^\circ = 14.45^\circ$

consider interface between fibre optic & air



$$n_A \sin\theta_A = n_1 \sin\theta_1'$$

$$\theta_A = \sin^{-1}\left[\left(\frac{n_1}{n_A}\right)\sin(14.45)\right]$$

$$= \sin^{-1}\left((1.58)(0.25)\right)$$

$$= 23.2^\circ$$

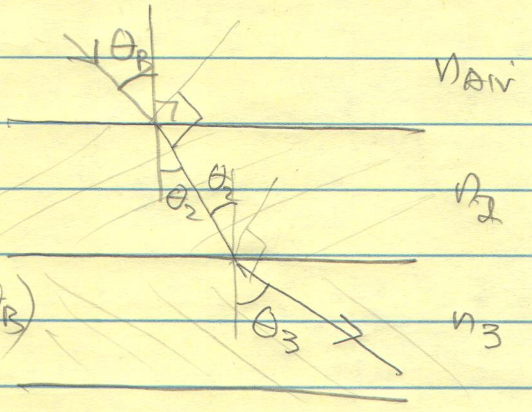
(10)

33-70

At Brewster angle entrance

$\theta_2 = 90 - \theta_B$

Apply Snell's law



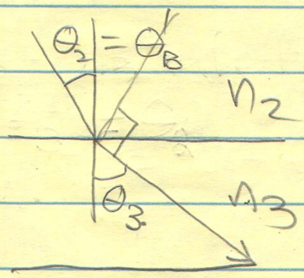
$n_A \sin\theta_B = n_2 \sin\theta_2 = n_2 \sin(90-\theta_B)$

$= n_2 \cos\theta_B$ with $n_A = 1$

$n_2 = \tan\theta_B$

$\theta_B = \tan^{-1} n_2 = \tan^{-1}(1.5) = 56.3°$

$\theta_2 = 90 - 56.3° = 33.7°$



Consider interface between n_2 & n_3

$\theta_3 = 90 - \theta_2$

$n_2 \sin\theta_2 = n_3 \sin\theta_3$

$n_2 = n_3 \sin(90-\theta_2) = n_3 \cos\theta_2$

$n_3 = n_2 \dfrac{\sin\theta_2}{\cos\theta_2}$

$= n_2 \tan\theta_2$

$= (1.5)(\tan 33.7°)$ //