ch. 34 1, 5, 7, 12, 16, 18, 24, 25, 36, 37, 38, 40, 41
49, 51, 58, 59, 62

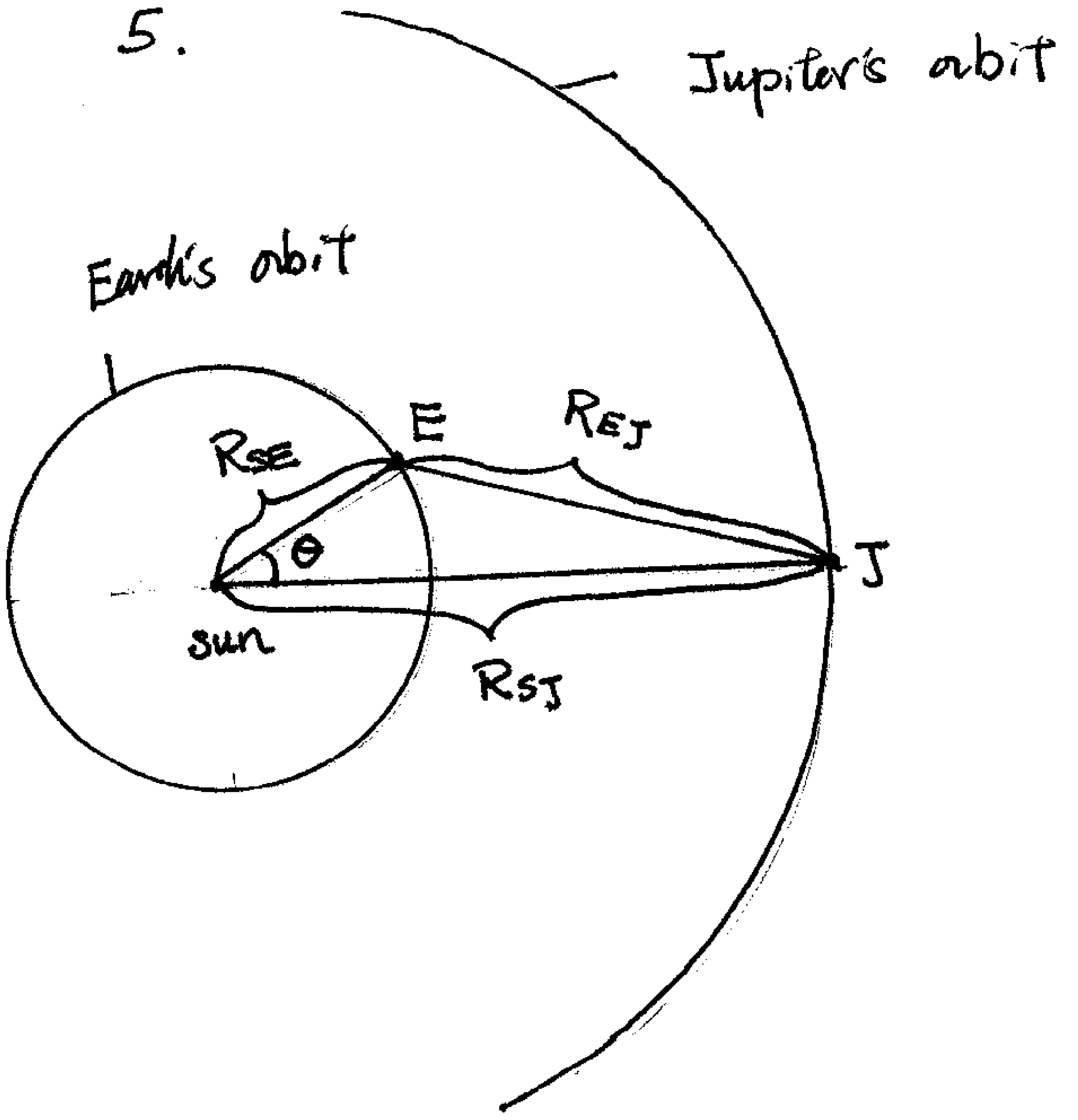
1. (a) $t = \frac{D}{V} = \frac{1.5 \times 10^5 m}{3.0 \times 10^8 m/sec} = \underline{\underline{5 \times 10^{-4} sec}}$

(b) $t = \frac{D}{V} = \frac{1.5 \times 10^8 km + 2 \times 3.5 \times 10^5 km}{3 \times 10^8 m/sec} = 502.\dot{3} sec = \underline{\underline{8.37\dot{2} min}}$

(c) $t = \frac{D}{V} = \frac{1.3 \times 10^9 km \times 2}{3 \times 10^5 km/sec} = 8666.\dot{6} sec = \underline{\underline{2.\dot{4}\dot{0}\dot{7} hrs}}$

(d) Dist. = 6500 lys → light Takes 6500 yrs to reach us.
⇒ super nova event happened 6500 yrs before 1054 A.D.
1054 AD − 6500 ~ $\underline{\underline{5446 BC}}$

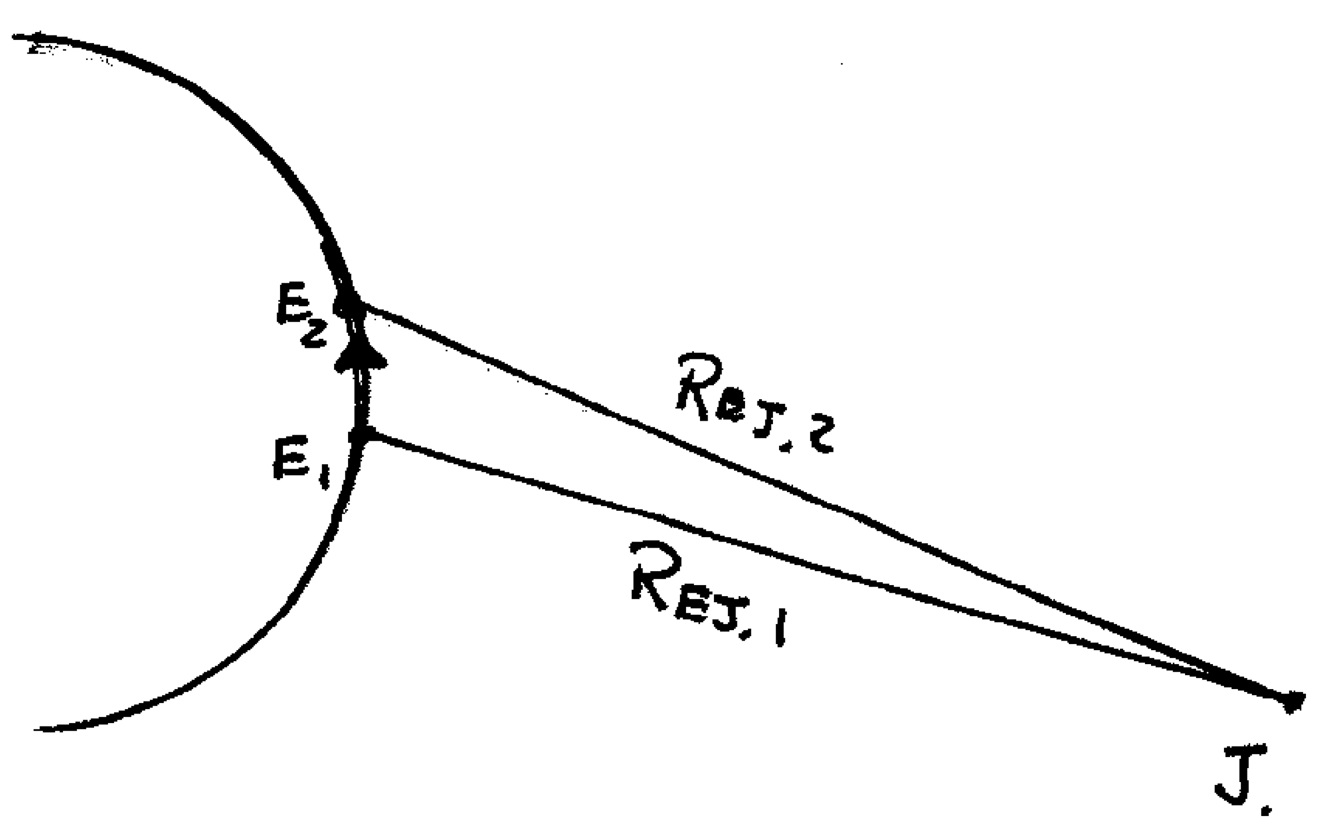
5.



R_{SE} : Dist. between the sun & Earth
R_{SJ} : Dist. between the sun & Jupiter
R_{EJ} : Dist. between Earth & Jupiter

θ : ∡ between R_{SE} & R_{SJ}

P : orbital Period of the Moon



at a certain time t_1, Jupiter's Moon is starting its cycle, but Earth does not observe this yet because light has to travel $R_{EJ,1}$ to reach us. So, Earth observes this at $t_1 + \frac{R_{EJ,1}}{c}$. while the Moon completes its cycle, Earth moves from E_1 to E_2. So the distance changes from $R_{EJ,1}$ to $R_{EJ,2}$

Earth observes the beginning of the second cycle at:

$$t_{2,E} = \underbrace{\left(t_1 + \frac{d_1}{c}\right)}_{t_{1,E}} + P + \left(\frac{R_{EJ,2} - R_{EJ,1}}{c}\right)$$

beginning of the 1st cycle — Delay — orbital period of the Moon — Extra delay because E-J dist. changed.

So, From the earth's observation, orbital Period of the Moon is

$$t_{2,E} - t_{1,E} = P + \left(\frac{R_{EJ,2} - R_{EJ,1}}{c}\right)$$

How far does the distance change ($R_{EJ,2} - R_{EJ,1}$) while the Moon orbits once? (see the first diagram)

$$R_{EJ}^2 = R_{SE}^2 + R_{SJ}^2 - 2 R_{SE} R_{SJ} \cos\theta \quad \text{(Law of cos)}$$

$$\therefore\ R_{EJ} = \left(R_{SE}^2 + R_{SJ}^2 - 2R_{SE}R_{SJ}\cos\theta\right)^{1/2}$$

to find the rate of change of R_{EJ} we do $\frac{d(R_{EJ})}{dt}$

$$\therefore\ \frac{d(R_{EJ})}{dt} = \frac{2R_{SE}R_{SJ}\sin\theta}{\left(R_{SE}^2 + R_{SJ}^2 - 2R_{SE}R_{SJ}\cos\theta\right)^{1/2}} \frac{d\theta}{dt}$$

(Also $R_{SE}\frac{d\theta}{dt}$ is the orbital speed of the earth

$$= \frac{2R_{SJ}\sin\theta}{\left(R_{SE}^2 + R_{SJ}^2 - 2R_{SE}R_{SJ}\cos\theta\right)^{1/2}} \cdot V_E$$

So, at the location "x", $\theta = 0$.

$$\frac{d(R_{EJ})}{dt} = 0.$$

Distance between E-J will not change (No change in period)

at "y", $\theta = 90°$

$$\frac{d(R_{EJ})}{dt} = \frac{2R_{SJ}V_E}{\left(R_{SE}^2 + R_{SJ}^2\right)^{1/2}}$$

(This is $\Delta R_{EJ} = R_{EJ,2} - R_{EJ,1}$)

$$t_{2,E} - t_{1,E} = P + \frac{2R_{SJ}V_E}{c\left(R_{SE}^2 + R_{SJ}^2\right)^{1/2}}$$

(b) at the location "X", we can measure "P", since there is no extra delay.

at the location "y", we need to know other variables

R_{SE}, R_{SJ}, V_E. & $(t_{2,E} - t_{1E})$ (earth observed period)

7.

$\lambda = 550\ nm = 550 \times 10^{-9} m$

$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8\ m/sec}{550 \times 10^{-9} m} = 5.\dot{4}\dot{5} \times 10^{14}\ Hz$

$\omega = 2\pi\nu = 3.427191986 \times 10^{15}\ rad/sec$

$\omega = \sqrt{\frac{1}{LC}} \Rightarrow \omega^2 = \frac{1}{LC}$

$L = \frac{1}{\omega^2 C} = \underline{\underline{5.008 \times 10^{-21}\ H}}$

12

$\oint I \cdot dA =$ Power of the source

$I = \frac{P_s}{4\pi r^2}$

$= \frac{1\ \mu w}{4\pi \left(4.3\ lys \cdot \frac{365.25\ days}{1\ yr} \cdot \frac{24\ 1.hour}{1\ 1.day} \cdot \frac{3600\ 1.s.}{1\ 1.h} \cdot \frac{3 \times 10^8\ m}{1\ 1.s}\right)^2}$

$= \underline{\underline{4.8 \times 10^{-29}\ w/m^2}}$

16.

$I_{rms} = 1.40\ kw/m^2$

$I = \frac{1}{\mu_0 c} E^2$

$\therefore E_{rms} = \sqrt{I_{rms} \cdot \mu_0 c} = 726.4878938\ N/c$

$\underline{\underline{E_{max} = \sqrt{2}\ E_{rms} = 1027.411861\ N/c}}$

$\underline{\underline{B_{max} = \frac{E_{max}}{c} = 3.42470620\text{2} \times 10^{-6}\ T}}$

18.

(a) $$P_{received} = \frac{P_{received\ by\ the\ Earth}}{A\ of\ the\ Earth} \cdot A_{antenna}$$

$$= \frac{1\times10^{-12}\,w}{4\pi\,(6.37\times10^{6}m)^2} \cdot \pi\cdot\left(\frac{300m}{2}\right)^2$$

$$= \underline{\underline{1.3862567113\times10^{-22}\,W}}$$

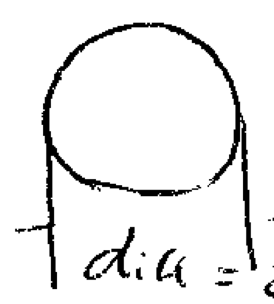
(b) $$P_s = I \cdot 4\pi r^2$$

$$= \frac{1\times10^{-12}\,W}{4\pi\,(6.37\times10^{6})^2} \cdot 4\pi \cdot \left((2.2\times10^{4}\,ly)(9.46\times10^{15}\,m/1y)\right)^2$$

$$= \underline{\underline{1.1\times10^{15}\,W.}}$$

24.

(a) $$I = \frac{P_s}{Area}$$



dia $= 2\lambda \Rightarrow r = \lambda$

$$= \frac{5\times10^{-3}\,w}{\pi\,(633\times10^{-9}m)^2}$$

$$= \underline{\underline{3.97231753\times10^{9}\,w/m^2}}$$

(b) $$P_r = \frac{I}{c} = 13.24\ N/m^2\ (Pa)$$

(c) $$F = P_r \cdot A$$

$$= 13.24\,N/m^2 \cdot \pi r^2$$

$$= 13.24\,N/m^2 \cdot \pi\,(6.33\times10^{-9}m)^2$$

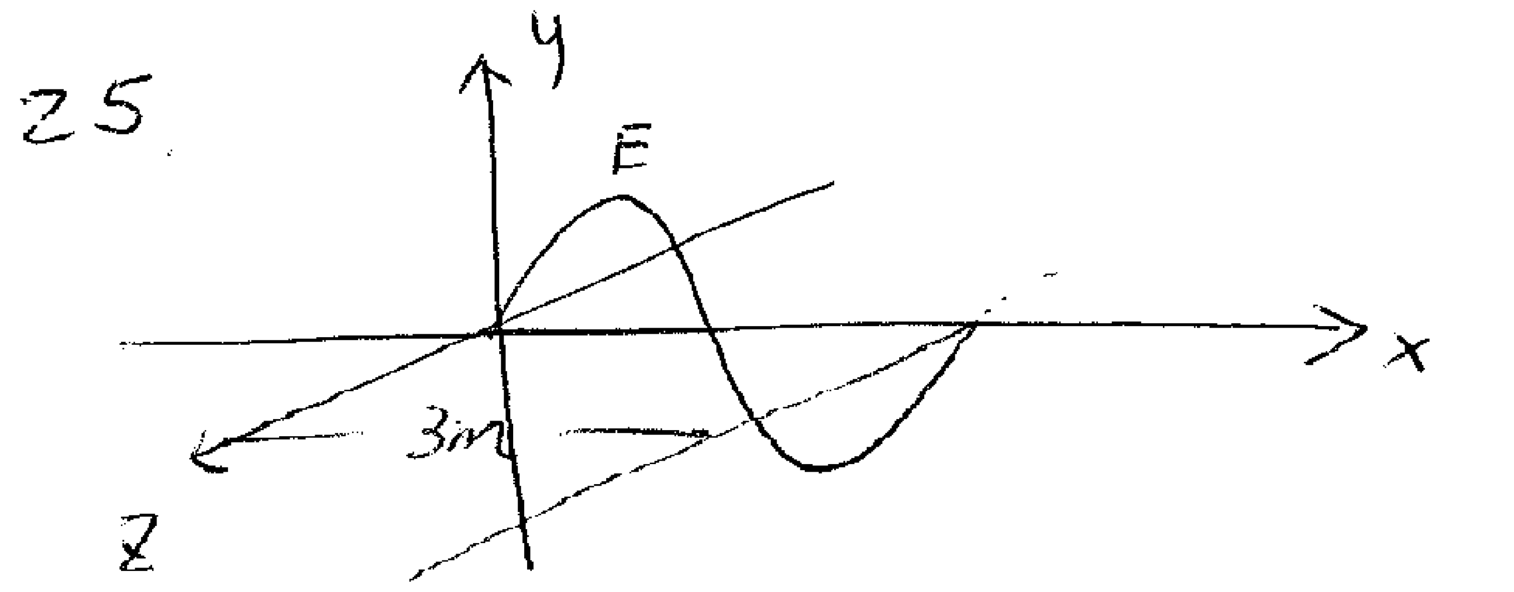
$$= \underline{\underline{1.\dot{6}\times10^{-11}\,N}}$$

(d) $$a = \frac{F}{m}$$

$$\left(m = \rho\cdot Vol = 5\times10^{3}\,kg/m^3 \cdot \frac{4}{3}\pi\,(6.33\times10^{-9})^3 = 5.31\times10^{-15}\,kg\right.$$

$$= \frac{1.\dot{6}\times10^{-11}\,N}{5.31\times10^{-15}\,kg} = \underline{\underline{3.13746583\times10^{3}\,m/sec^2}}$$

25.



$E = 300\ V/m$

(a) $C = \lambda \nu \Rightarrow \nu = \dfrac{c}{\lambda} = \dfrac{3\times10^8\ m/sec}{3m} = \underline{\underline{1\times10^8\ Hz}}$

(b) Since $\vec{E}\times\vec{B} = \vec{V}$ $\vec{B}$ has to be along z-axis & corresponds $\vec{E}$ (when $\vec{E}$ is positive, so is $\vec{B}$)

(c) $\dfrac{E_m}{B_m} = C \Rightarrow B_m = \dfrac{E_m}{c} = \dfrac{300\ V/m}{3\times10^8\ m/sec} = \underline{\underline{1\times10^{-6}\ T}}$

$E = E_{max} \sin(kx - \omega t)$

when $x = 3m$, it is one cycle so $kx \Rightarrow 2\pi$ rad

$3k = 2\pi$

$\underline{\underline{k = \dfrac{2\pi}{3}\ rad/m}}$

$\omega = 2\pi\nu = \underline{\underline{2\pi\times10^8\ rad/sec}}$

So

$\underline{\underline{E = E_{max} \sin\left(\dfrac{2\pi}{3}x - 2\pi\times10^8 t\right)}}$

(d) $I = \dfrac{(E_{rms})^2}{\mu_0 c} = \dfrac{\left(\frac{E_{max}}{\sqrt{2}}\right)^2}{\mu_0 c} = \dfrac{(E_{max})^2}{2\mu_0 c} = \dfrac{(300\ V/m)^2}{2\cdot 4\pi\times10^{-7}\ 3\times10^8}$

$= \underline{\underline{119.3662073\ W/m^2}}$

(e) $\dfrac{dp}{dt} = F = \dfrac{IA}{c} = \dfrac{119.366\cdot 2}{3\times10^8} = \underline{\underline{7.957747155\times10^{-7}\ N}}$

$P_r = \dfrac{F}{A} = \dfrac{I}{c} = \dfrac{119.366}{3\times10^8} = \underline{\underline{3.978873577\times10^{-7}\ N/m^2\ (Pa)}}$

36.

$I_1 = I_o \cos^2\theta$

$I_2 = I_1 \cos^2(90-\theta) = 0.1\ I_o$

$0.1\ I_o = I_o \cos^2\theta\ \underbrace{\cos(90-\theta)}$

$0.1 = \cos^2\theta\ \sin^2\theta$

$(\cos\theta\ \sin\theta) = \sqrt{0.1}$

$\cancel{\sin(\frac{\theta}{2}) = \sqrt{0.1}}$ $\quad \frac{1}{2}\sin(2\theta) = \sqrt{0.1}$

$\cancel{\frac{\theta}{2} = \sin^{-1}\sqrt{0.1}}$ $\quad 2\theta = \sin^{-1}(2\sqrt{0.1})$

$\theta = \frac{1}{2}\sin^{-1}(2\sqrt{0.1})$

$\cancel{\theta = 2\sin^{-1}(\sqrt{0.1}) = 36.^{\circ}86989765}$ $\quad \therefore \theta = 19.^{\circ}61576009$

37

$I_1 = I_o \cos^2 70^\circ$

$I_2 = I_1 \cos^2(90^\circ - 70^\circ)$

$I_2 = I_o \cos^2 70^\circ \cos^2 20^\circ$

$= 43\ W/m^2\ \cos^2 70^\circ \cos^2 20^\circ$

$= 4.44164164 5\ W/m^2$

38.

$I_1 = \frac{1}{2} I_o$

$I_2 = I_1 \cos^2(90^\circ - 70^\circ)$

$= \frac{1}{2} I_o \cos^2(90^\circ - 70^\circ)$

$= \frac{1}{2}\ 43\ W/m^2\ \cos^2(20^\circ)$

$= 18.98497776\ W/m^2$

40. $E_{\text{Total before}} = (E_x, E_y) = (2.3 \text{ units}, 1 \text{ unit})$

$E_{\text{Total after}} = (E_x, E_y) = (0, 1 \text{ unit})$

$I_{\text{Total before}} \propto \sum E_i^2 = 6.29 \text{ units}$ $\quad (I = \frac{1}{\mu_0 c} E^2)$

$I_{\text{Total after}} \propto \sum E_i^2 = 1 \text{ unit}$

(a) $\frac{I_{\text{after}}}{I_{\text{before}}} = \frac{1}{6.29} = \underline{\underline{0.15898 \times}}$

(b) the vertical polarizer is now horizontal

$E_{\text{Total after}} = (E_x, E_y) = (2.3 \text{ units}, 0)$

$I_{\text{Total after}} \propto = \sum E_i^2 = 5.29 \text{ units}$

$\therefore \frac{I_{\text{after}}}{I_{\text{before}}} = \frac{5.29}{6.29} = \underline{\underline{0.841017488 \times}}$

41

(a) 2 sheets

(b) to pass the maximum intensity each filter should be set w/ a minimum $\measuredangle$ (because of $\cos^2\theta$).
However if one $\measuredangle$ is very small, we have to end up w/ $90°$ net, other $\measuredangle$ might be large. To optimize this, each θ should be the same.

ex. · 2 sheets. (each should be $90°/2 = 45°$)

$I_1 = I_0 \cos^2 45° = \frac{1}{2} I_0$

$I_2 = I_1 \cos^2 45° = \frac{1}{2} I_0 \cdot \frac{1}{2} = \frac{1}{4} I_0$ — $\underline{25\%}$ (Not enough)

· 3 sheets ($\theta = 30°$)

$I_1 = I_0 \cos^2 30°$

$I_2 = I_1 \cos^2 30° = I_0 \cos^2 30° \cdot \cos^2 30°$

$I_3 = I_2 \cos^2 30° = I_0 \cos^2 30° \cdot \cos^2 30° \cdot \cos^2 30° = I_0 (\cos^2(\frac{90}{n}))^n = 0.421875 I_0$

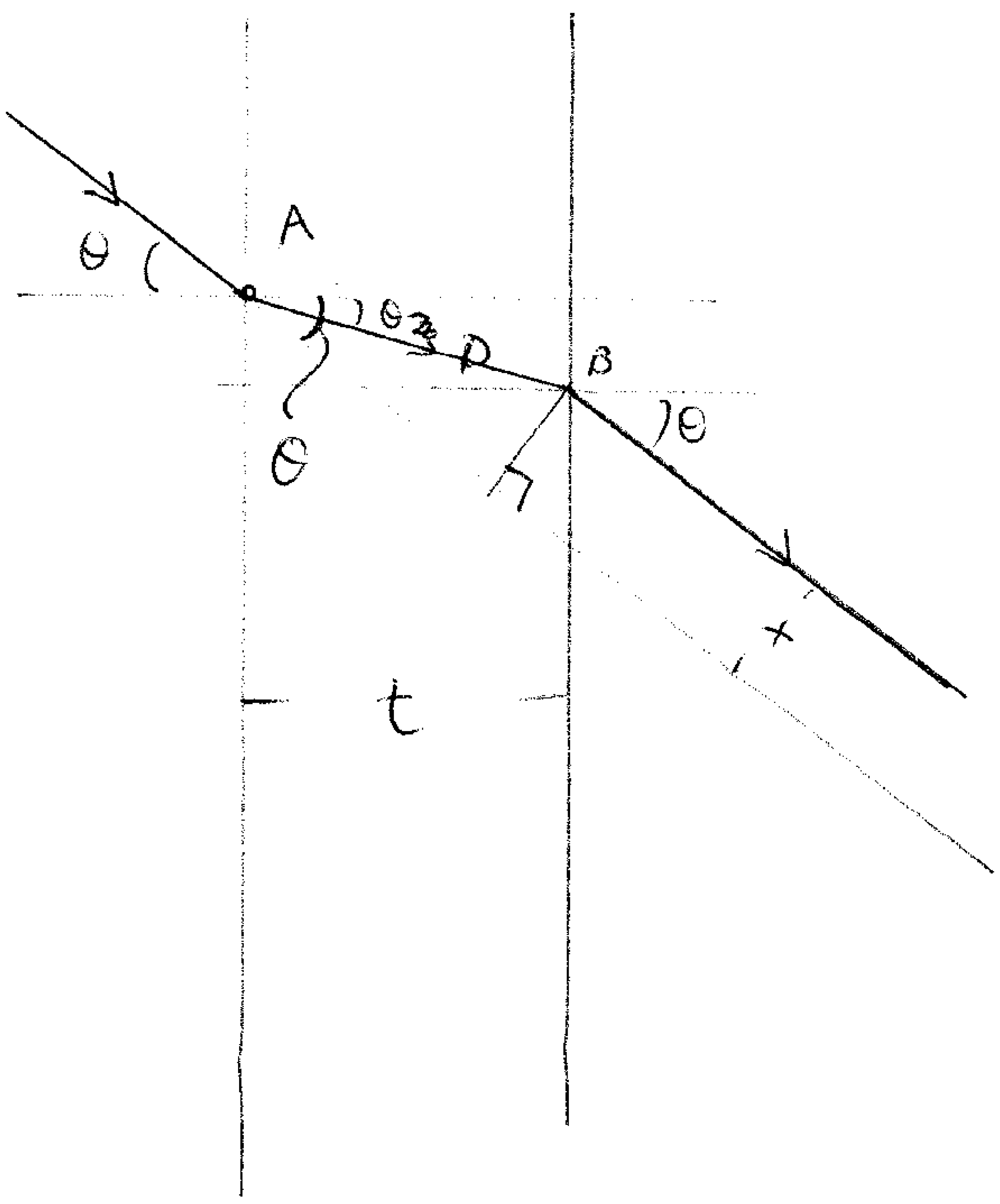
· 4 sheets

$I_4 = I_0 (\cos^2(\frac{90}{4}))^4 = 0.53079 I_0$

5 sheets

$$I_5 = I_0 \left(\cos^2\left(\frac{90}{5}\right)\right)^5 = \underline{60.5429\, I_0 \; !}$$

49



at the point A:

$$\cancel{n_{air}}' \cancel{\sin}\, \theta = n \cancel{\sin\theta_2}\, \theta_2 \qquad \begin{pmatrix} \sin\theta \sim \theta \\ \sin\theta_2 \sim \theta_2 \end{pmatrix}$$

$$\theta_2 = \frac{\theta}{n} \quad \text{—} \; ①$$

Let $\overline{AB} = D$

$$\cos\theta_2 = \frac{t}{D}$$

$$D = \frac{t}{\cos\theta_2} \sim t \quad \text{—} \; ②$$

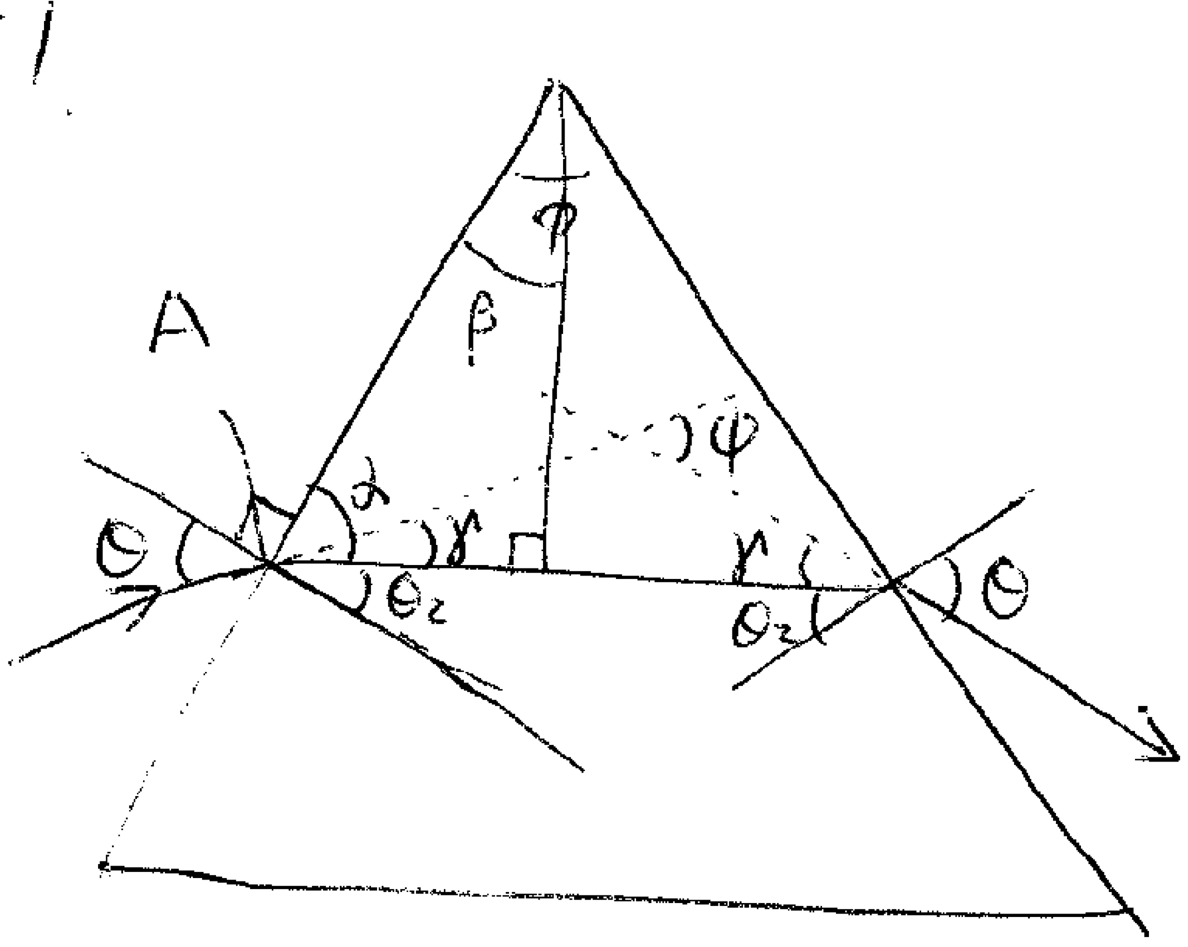
$$X = D \sin(\theta - \theta_2) \Leftarrow ① \; \& \; ②$$

$$\sim t \sin\left(\theta - \frac{\theta}{n}\right)$$

$$= t \sin\left(\theta \frac{n-1}{n}\right)$$

$$\sim t\, \theta\, \frac{n-1}{n} \qquad \sin\left(\theta \frac{n-1}{n}\right) \sim \theta \frac{n-1}{n}$$

51



$$n' \sin\theta = n \sin\theta_2$$

$$\therefore n = \frac{\sin\theta}{\sin\theta_2} \stackrel{?}{=} \frac{\sin\frac{1}{2}(\psi + \phi)}{\sin\frac{1}{2}\phi}$$

So let us prove $\theta = \frac{1}{2}(\psi + \phi)$

& $\theta_2 = \frac{1}{2}\phi$.

at point A

$\alpha + \theta_2 = 90^\circ \Rightarrow \beta = \theta_2$ (because $\alpha + \beta = 90^\circ$)

the same thing happens on the left triangle at the summit

$\therefore \phi = 2\beta = 2\theta_2 \Rightarrow \underline{\theta_2 = \frac{1}{2}\phi}$

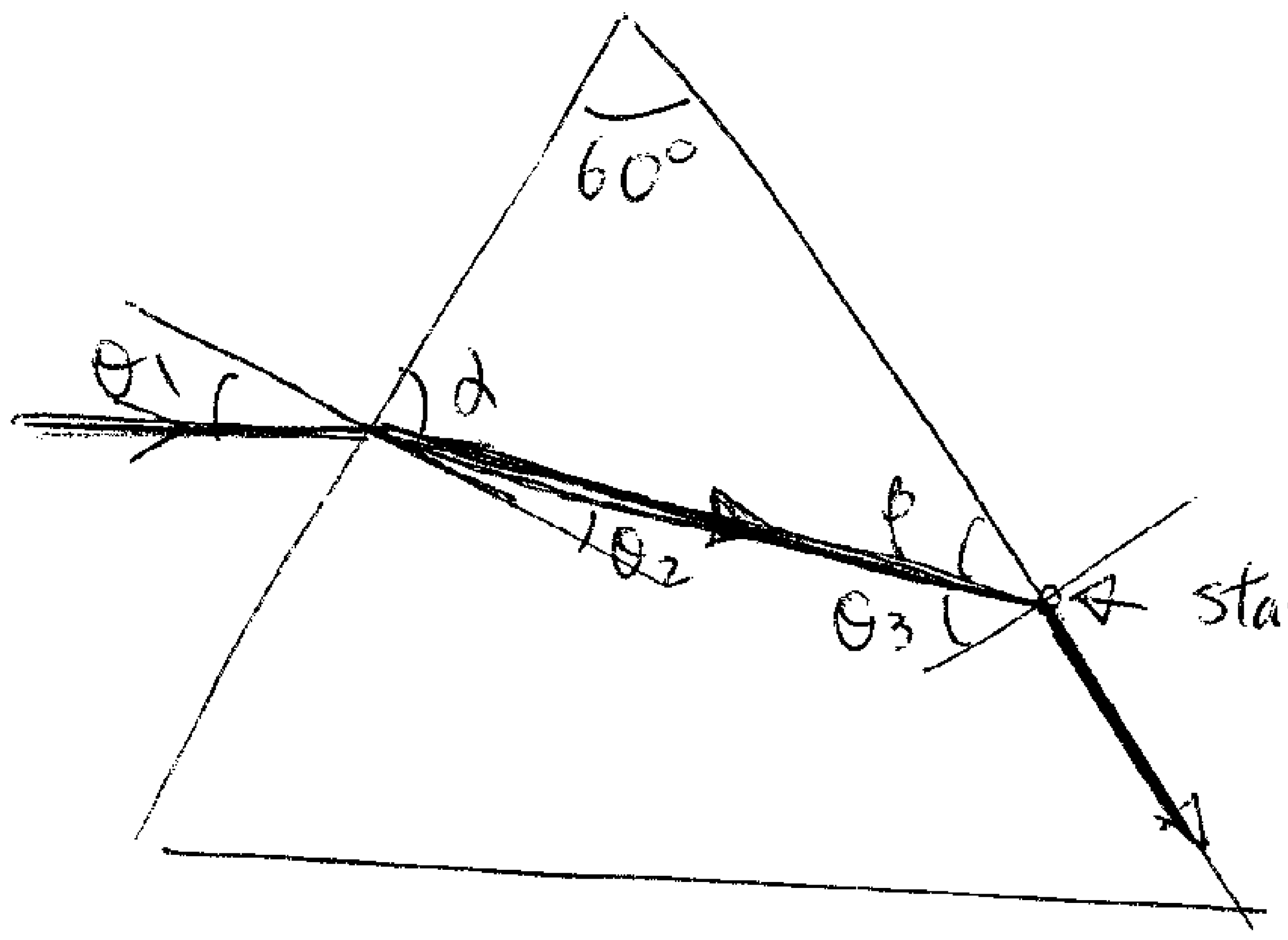
$$2\gamma = \psi \Rightarrow \gamma = \tfrac{1}{2}\psi$$

And

$$\theta = \gamma + \theta_2 = \tfrac{1}{2}\psi + \tfrac{1}{2}\phi = \underline{\underline{\tfrac{1}{2}(\psi+\phi)}}$$

$$\therefore\ n = \frac{\sin\theta}{\sin\theta_2} = \frac{\sin\tfrac{1}{2}(\psi+\phi)}{\sin\tfrac{1}{2}\phi}$$

58.



(a)

$$n\sin\theta_3 = \sin 90^\circ$$

$$\theta_3 = \sin^{-1}\frac{1}{1.6} = 38.^\circ 682$$

$$\theta_3 + \beta = 90^\circ \Rightarrow \beta = 51.^\circ 3178$$

$$\alpha + \beta + 60^\circ = 180^\circ \Rightarrow \alpha = 68.^\circ 68$$

$$\alpha + \theta_2 = 90^\circ \Rightarrow \theta_2 = 21.^\circ 3178$$

$$\sin\theta_1 = n\sin\theta_2$$

$$\theta = \sin^{-1}(n\sin\theta_2)$$

$$= \sin^{-1}(1.6\sin(21.^\circ 3178))$$

$$= \underline{\underline{35.^\circ 56776223}}$$

(b) To have a beam like #51, $\alpha = \beta = 60^\circ$ $(\theta_2 = \theta_3 = 30^\circ)$

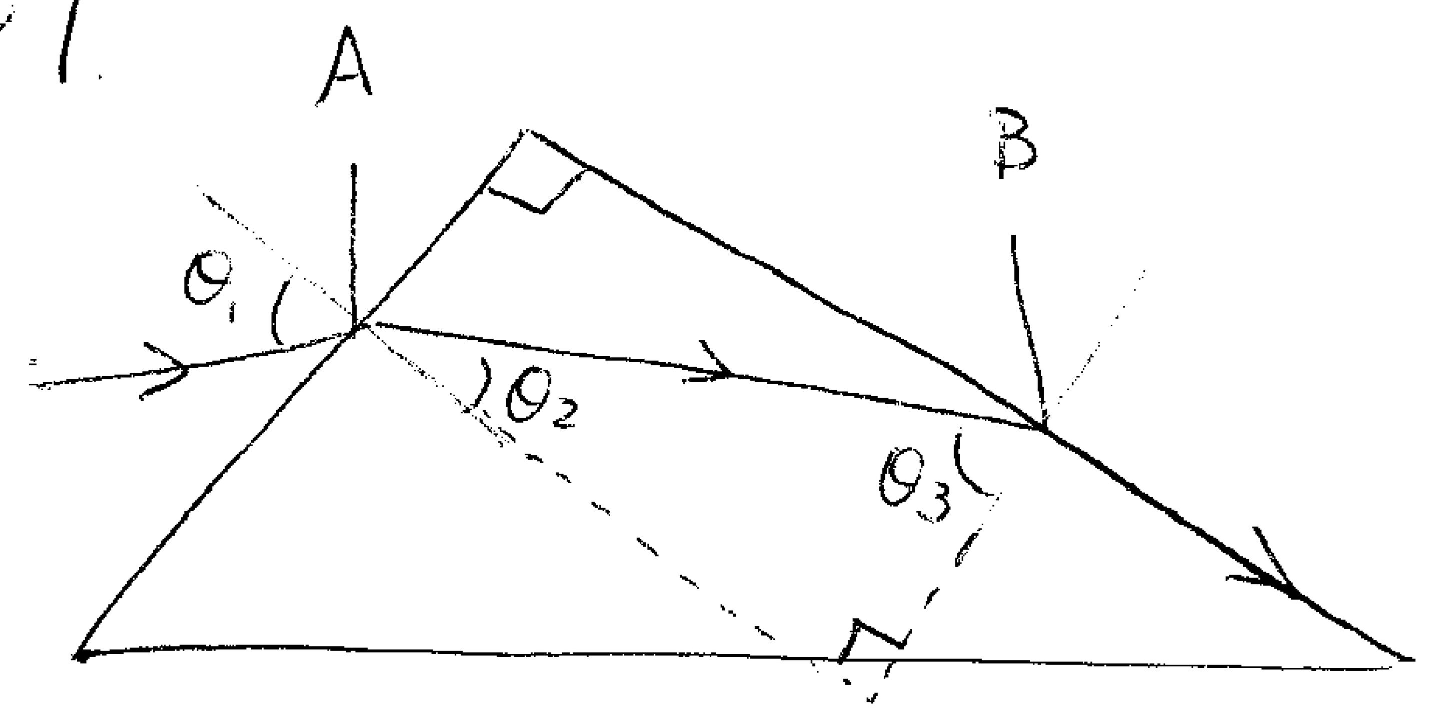
$$\theta_1 = \sin^{-1}(n\sin 30^\circ)$$

$$= \sin^{-1}(1.6 \cdot 0.5)$$

$$= \sin^{-1}(0.8)$$

$$= \underline{\underline{55.^\circ 1}}$$

59.



(a) point A

$$1 \sin\theta_1 = n \sin\theta_2 \longrightarrow \sin\theta_2 = \frac{\sin\theta_1}{n} \quad — ①$$

point B

$$n \sin\theta_3 = 1 \sin \cancel{90°}1 \quad \& \quad \theta_3 = 90 - \theta_2$$

$$\Rightarrow n \sin(90-\theta_2) = 1$$

$$n \cos\theta_2 = 1 \rightarrow \cos\theta_2 = \frac{1}{n} \quad — ②$$

$$①^2 + ②^2 = 1$$

$$\left(\frac{\sin\theta_1}{n}\right)^2 + \left(\frac{1}{n}\right)^2 = 1$$

$$\sin^2\theta_1 + 1 = n^2$$

$$\therefore n = \sqrt{\sin^2\theta_1 + 1}$$

(b) max $\sin\theta_1 = 1$

$$\therefore n = \sqrt{1^2+1} = \sqrt{2}$$

(c) θ_3 increased $\rightarrow$ Total internal reflection

decreased $\rightarrow$ some will be refracted into the air

62. page 820, Fig. 34–19.

$n_{400nm} = 1.47$

$n_{700nm} = 1.456$

$\theta_{B,400nm} = \tan^{-1} 1.47 = \underline{\underline{55.77^\circ}}$

$\theta_{B,700nm} = \tan^{-1} 1.456 = \underline{\underline{55.52^\circ}}$