33-3

lower $\frac{1}{2}$ max sensitivity at $\lambda \sim 510\,nm$

upper $\frac{1}{2}$ max sensitivity at $\lambda \sim 610\,nm$

max sensitivity at $\lambda \sim 555\,nm$

$$f\lambda = c$$
$$f(555\times10^{-9}\,m) = 3\times10^{8}$$
$$f = 5.41\times10^{14}\,Hz$$
$$T = \frac{1}{f} = 1.85\times10^{-15}\,sec$$

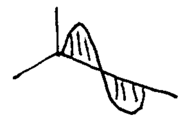
33-4 1 nsec

distance $\sim$ speed $\cdot$ time
$$\sim 3\times10^{8}\quad 10^{-9}$$
$$\sim 0.3\,m$$
$$\sim 30\,cm$$
$\sim$ 12 inches

$\sim$ 1 foot

This is a useful thing to remember when working with coaxial cable, network cable, etc..

33-12



$E_m = 5\ V/m$

a) Magnetic field amplitude $B_m = \frac{E_m}{c}$
$$= \frac{5}{3\times10^{8}}$$
$$= 1.67\times10^{-8}\ \text{Tesla}$$

b) Intensity

Intensity = Ave Poynting Vector $= \frac{1}{2}\epsilon_0 c E_m^2$
$$= \frac{1}{2}(8.85\times10^{-12})(3\times10^{8})\,5^2$$
$$= 3.32\times10^{-2}\ \text{Watts}/m^2$$

33-13

$I = 1.4\ kW/m^2 = 1400\ W/m^2$

a) Intensity = Ave Poynting Vector $= \frac{1}{2}\epsilon_0 c E_m^2$
$$1400 = \frac{1}{2}(8.85\times10^{-12})(3\times10^{8})E_m^2$$
$$E_m = 1.03\times10^{3}\ V/m$$

b) $B_m = \frac{E_m}{c} = \frac{1.03\times10^{3}}{3\times10^{8}}$
$$= 3.42\times10^{-6}\ \text{Tesla}$$

33-19

laser

peak power 1.5×10^{3} mW

Sample Area $= 1\ mm^2$

$= 1\,(10^{-3}\,m)^2$

$= 10^{-6}\,m^2$

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}} = \frac{1.5\times10^{3}\times10^{6}\ \text{Watts}}{10^{-6}\ m^2}$$

$$= 1.5\times10^{15}\ \text{watts}/m^2$$

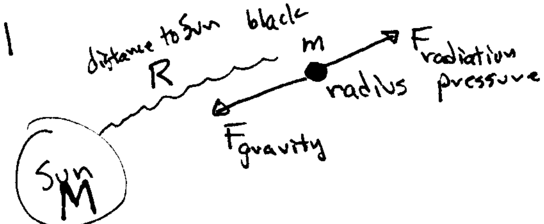
"pressure" in laser beam $= p = \frac{I}{c}$

because the laser light is completely reflected, the pressure on the sample is

$$\frac{2I}{c} = \frac{2(1.5\times10^{15})}{3\times10^{8}}$$

$$= 1\times10^{7}\ \text{Pascal}$$

33-31



We want to balance these two forces

$$F_{gravity} = F_{radiation\ pressure}$$

$$G\frac{mM}{R^2} = P\cdot \text{Area}$$

$$G\frac{mM}{R^2} = \frac{I}{c}A$$

The mass of the dust particle is

$m = \rho \cdot \text{vol}$

$= \rho \frac{4}{3}\pi r^3$

The intensity decreases as one moves away from Sun

$$I = \frac{\text{Power Sun}}{4\pi R^2}$$

$A = \pi r^2$

Putting it together

$$G\frac{\rho\frac{4}{3}\pi r^3 M}{R^2} = \frac{\frac{P_{sun}}{4\cancel{\pi} R^2}\cancel{\pi} r^2}{c}$$

solving for r

$$r = \frac{\cancel{R^2}}{G\rho\frac{4}{3}\pi M}\ \frac{P_{sun}}{4\cancel{R^2}c}$$

$$= \frac{3P_{sun}}{G\rho\,16\pi M c}$$

The power output of the Sun is 3.9×10^{26} Watts Book Appendix C

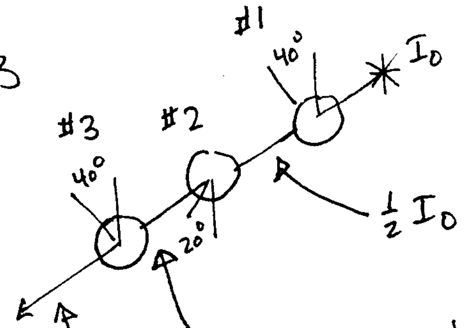
$M_{sun} = 1.99\times10^{30}$ kg

$\rho = 3.5\times10^{3}\ kg/m^3$

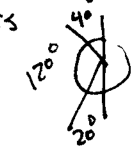
$\rightarrow r = 1.7\times10^{-7}$ m

If the dust particle is larger, the gravitation force will dominate & trajectory will go toward sun.

33-33

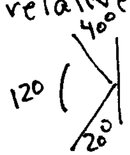


The relative angle between filter #1 & #2 is 120°



$$\left[\tfrac{1}{2} I_0\right] \cos^2 120^\circ$$

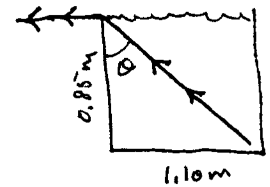
The relative angle between the 2nd & 3rd filter is 120°



$$\left[\tfrac{1}{2} I_0 \cos^2 120^\circ\right] \cos^2 120^\circ$$

$$(3.13 \times 10^{-2})\, I_0$$

33-45



$$\tan\theta = \frac{1.10}{0.85}$$

$$\theta = 52.3^\circ$$

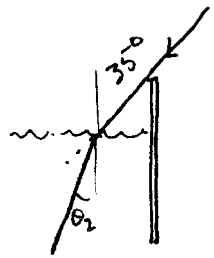
Then apply Snells Law

$$n_{air} \sin\theta_{air} = n_{liquid} \sin\theta_{liquid}$$

$$1 \sin 90^\circ = n_{liquid} \sin 52.3^\circ$$

$$n_{liquid} = 1.26$$

33-55



We are given the wrong angle 55°

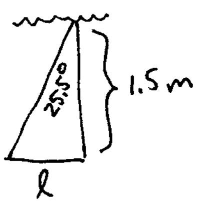
$\theta_{incident} = 90 - 55 = 35°$

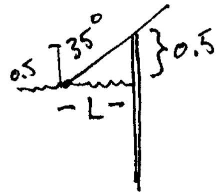
The ray drawn defines the edge of the shadow

$n_{air} \sin\theta_{air} = n_{water} \sin\theta_{water}$

$1 \sin 35° = 1.33 \sin\theta_{water}$

$\theta_{water} = 25.5°$





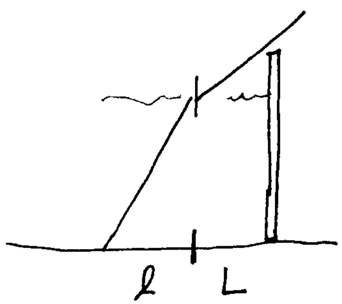
$\tan 25.5° = \frac{l}{1.5}$

$l = 0.715\text{ m}$

$\tan 35° = \frac{L}{0.5}$

$L = 0.350$

The total distance along the bottom of the pool

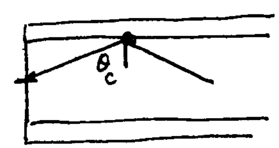


$l + L = 0.715 + 0.350$

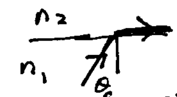
$= 1.065\text{ m}$

$= 1.07\text{ m}$

33-65



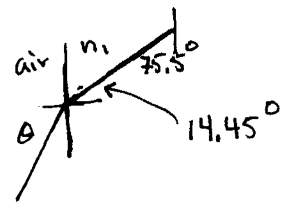
Total internal reflection at the $n_1 - n_2$ boundary



$n_1 \sin\theta_c = n_2 \sin 90°$

$1.58 \sin\theta_c = 1.53 \sin 90°$

$\theta_c = 75.5°$

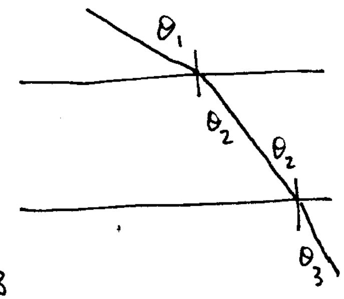


$n_{air} \sin\theta = n_2 \sin\theta_2$

$1 \sin\theta = 1.58 \sin 14.45°$

$\theta = 23.2°$

33-70



$n_1 = 1$
$n_2 = 1.5$
$n_3 = ?$

The angle θ_1 is the Brewster angle

$$\cancel{\tan\theta_1 = n_2 \text{ for air}}$$
$$\tan\theta_1 = 1.5$$
$$\theta_1 = 56.3^\circ$$

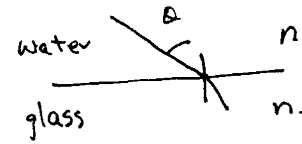
We can now calculate θ_2

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$1 \sin 56.3^\circ = 1.5 \sin\theta_2$$
$$\theta_2 = 33.7^\circ$$

The angle θ_2 is the Brewster angle

$$\cancel{\tan\theta_2 = n_3 \text{ for air}}$$
$$\tan\theta_2 = \frac{n_3}{n_2}$$
$$\tan 33.7^\circ = \frac{n_3}{1.5}$$
$$n_3 = 1.0$$

33-69



$n_1 = 1.33$
$n_2 = 1.53$

The angle θ_1 is Brewster angle

$$\cancel{\tan\theta_1 = n_2 \text{ for air}}$$
$$\tan\theta_1 = \frac{n_2}{n_1}$$
$$\tan\theta_1 = \frac{1.53}{1.33}$$
$$\theta = 49.0^\circ$$

33-3

lower $\frac{1}{2}$ max sensitivity at $\lambda \sim 510$ nm

upper $\frac{1}{2}$ max sensitivity at $\lambda \sim 610$ nm

max sensitivity at $\lambda \sim 555$ nm

$$f\lambda = c$$
$$f(555\times10^{-9}\,m) = 3\times10^{8}$$
$$f = 5.41\times10^{14}\ Hz$$
$$T = \frac{1}{f} = 1.85\times10^{-15}\ sec$$

33-4 1 nsec

distance $\sim$ speed $\cdot$ time
$\sim 3\times10^{8}\quad 10^{-9}$
~ 0.3 m
~ 30 cm
~ 12 inches
~ 1 foot

This is a useful thing to remember when working with coaxial cable, network cable, etc ..

33-12

$E_m = 5$ V/m

a) Magnetic field amplitude $B_m = \frac{E_m}{c} = \frac{5}{3\times10^{8}} = 1.67\times10^{-8}$ Tesla

b) Intensity

Intensity = Ave Poynting Vector $= \frac{1}{2}\epsilon_0 c E_m^2$
$= \frac{1}{2}(8.85\times10^{-12})(3\times10^{8})\,5^2$
$= 3.32\times10^{-2}$ Watts/m^2

33-13

$I = 1.4\ kW/m^2 = 1400\ W/m^2$

a) Intensity = Ave Poynting Vector $= \frac{1}{2}\epsilon_0 c E_m^2$

$1400 = \frac{1}{2}(8.85\times10^{-12})(3\times10^{8})E_m^2$

$E_m = 1.03\times10^{3}$ V/m

b) $B_m = \frac{E_m}{c} = \frac{1.03\times10^{3}}{3\times10^{8}}$
$= 3.42\times10^{-6}$ Tesla

33-19

laser

peak power 1.5×10^{3} mW

Sample Area $= 1\ mm^2 = 1\,(10^{-3}m)^2 = 10^{-6}\ m^2$

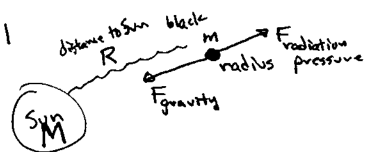
Intensity $= \frac{Power}{Area} = \frac{1.5\times10^{3}\times10^{6}\ Watts}{10^{-6}\ m^2}$
$= 1.5\times10^{15}$ watts/m^2

"pressure" in laser beam $= p = \frac{I}{c}$

because the laser light is completely reflected, the pressure on the sample is

$$\frac{2I}{c} = \frac{2(1.5\times10^{15})}{3\times10^{8}} = 1\times10^{7}\ \text{Pascal}$$

33-31



we want to balance these two forces

$$F_{gravity} = F_{radiation\ pressure}$$
$$G\frac{mM}{R^2} = P\cdot Area$$
$$G\frac{mM}{R^2} = \frac{I}{c}A$$

The mass of the dust particle is
$m = \rho\cdot Vol$
$= \rho\,\frac{4}{3}\pi r^3$

The intensity decreases as one moves away from Sun
$I = \frac{\text{Power Sun}}{4\pi R^2}$

$A = \pi r^2$

Putting it together

$$G\,\frac{\rho\,\frac{4}{3}\pi r^3 M}{R^2} = \frac{\frac{P_{sun}}{4\cancel{\pi}R^2}\cancel{\pi}r^2}{c}$$

solving for r

$$r = \frac{\cancel{R^2}}{G\rho\frac{4}{3}\pi M}\;\frac{P_{sun}}{4\cancel{R^2}c}$$
$$= \frac{3P_{sun}}{G\rho\,16\pi Mc}$$

The power output of the Sun is 3.9×10^{26} Watts

$M_{sun} = 1.99\times10^{30}$ kg

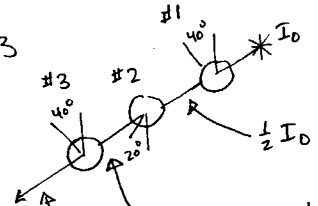
$\rho = 3.5\times10^{3}$ kg/m^3

Book Appendix C

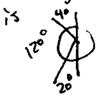
$\rightarrow r = 1.7\times10^{-7}$ m

If the dust particle is larger, the gravitation force will dominate & trajectory will go toward sun.

33-33

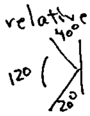


The relative angle between filter #1 & #2 is 120°



$$\left[\tfrac{1}{2} I_0\right] \cos^2 120^\circ$$

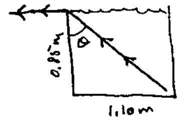
The relative angle between the 2nd & 3rd filter is 120°



$$\left[\tfrac{1}{2} I_0 \cos^2 120^\circ\right] \cos^2 120^\circ$$

$$(3.13 \times 10^{-2})\, I_0$$

33-45



$$\tan\theta = \frac{1.10}{0.85}$$

$$\theta = 52.3^\circ$$

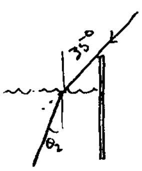
Then apply Snells Law

$$n_{air} \sin\theta_{air} = n_{liquid} \sin\theta_{liquid}$$

$$1 \sin 90^\circ = n_{liquid} \sin 52.3^\circ$$

$$n_{liquid} = 1.26$$

33-55



We are given the wrong angle 55°

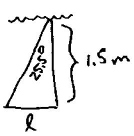
$$\theta_{incident} = 90 - 55 = 35^\circ$$

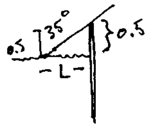
The ray drawn defines the edge of the shadow

$$n_{air} \sin\theta_{air} = n_{water} \sin\theta_{water}$$

$$1 \sin 35^\circ = 1.33 \sin\theta_{water}$$

$$\theta_{water} = 25.5^\circ$$





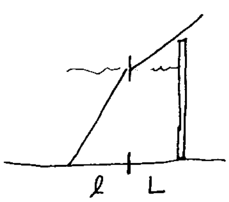
$$\tan 25.5^\circ = \frac{\ell}{1.5}$$

$$\ell = 0.715\text{ m}$$

$$\tan 35^\circ = \frac{L}{0.5}$$

$$L = 0.350$$

The total distance along the bottom of the pool

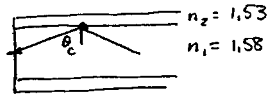


$$\ell + L = 0.715 + 0.350$$

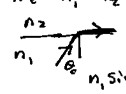
$$= 1.065\text{ m}$$

$$= 1.07\text{ m}$$

33-65



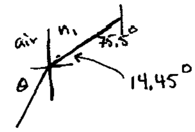
Total internal reflection at the $n_1 - n_2$ boundary



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

$$1.58 \sin\theta_c = 1.53 \sin 90^\circ$$

$$\theta_c = 75.5^\circ$$

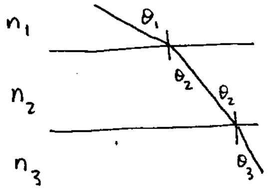


$$n_{air} \sin\theta = n_2 \sin\theta_2$$

$$1 \sin\theta = 1.58 \sin 14.45^\circ$$

$$\theta = 23.2^\circ$$

33-70



$n_1 = 1$
$n_2 = 1.5$
$n_3 = ?$

The angle θ_1 is the Brewster angle

$$\tan\theta_1 = n_2 \quad \text{for air}$$
$$\tan\theta_1 = 1.5$$
$$\theta_1 = 56.3^\circ$$

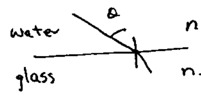
We can now calculate θ_2

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$1 \sin 56.3^\circ = 1.5 \sin\theta_2$$
$$\theta_2 = 33.7^\circ$$

The angle θ_2 is the Brewster angle

$$\cancel{\tan\theta_2 = n_3 \text{ for air}}$$
$$\tan\theta_2 = \frac{n_3}{n_2}$$
$$\tan 33.7^\circ = \frac{n_3}{1.5}$$
$$n_3 = 1.0$$

33-69



$n_1 = 1.33$
$n_2 = 1.53$

The angle θ_1 is Brewster angle

$$\cancel{\tan\theta_1 = n_2 \text{ for air}}$$
$$\tan\theta_1 = \frac{n_2}{n_1}$$
$$\tan\theta_1 = \frac{1.53}{1.33}$$
$$\theta = 49.0^\circ$$