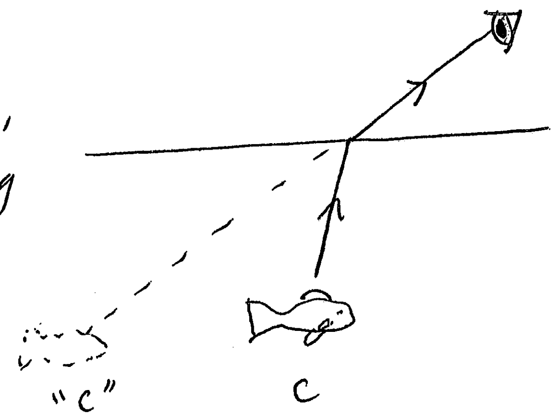
(c) (3 pts) If the person wants to shoot fish "C" and compensate for refraction, should he aim directly at the apparent location of the fish, or should he aim higher or lower? Explain.

the light from the fish will refract as it leaves the water, bending as shown, producing an image of the fish further away than it actually is; therefore, he should aim lower.



Hwk 10 Solutions PHYS 142 Summer '09 Dr. Jenkins

Problem 35.3

time for light to make round trip (use precise value found):

$$t = \frac{2d}{c} = \frac{2(11.45\times10^3\,m)}{2.998\times10^8\,m/s} = 7.638\times10^{-5}\,s$$

want light to leave through one notch and arrive at the next; angle between 2 gaps is

$$\theta = \frac{2\pi}{720} = 0.008727\ rad$$

this angle needs to match ωt

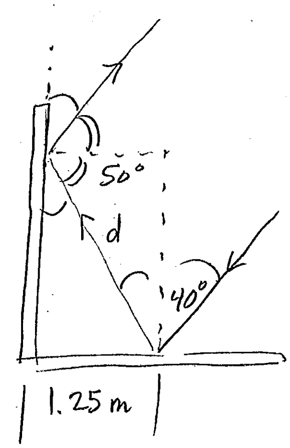
$$\theta = \omega t \Rightarrow \omega = \frac{\theta}{t} = \frac{(0.008727)}{(7.638\times10^{-5}\,s)} = 114.2\ rad/s$$

Problem 35.5

(a) reflected angle matches incident angle:

$$\Rightarrow \sin\theta = \frac{1.25\,m}{d}$$

$$\Rightarrow d = \frac{1.25\,m}{\sin 40°} = 1.94\,m$$

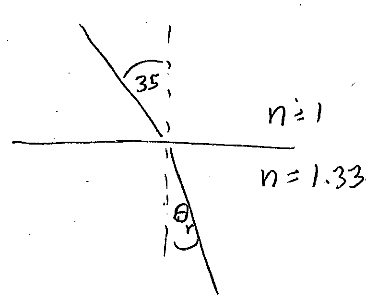


(b) light leaves at 50° above horizontal

Problem 35.9

Snell's law for angle:

$$\sin\theta_r = \frac{n_i}{n_r}\sin\theta_i = \frac{3}{4}\sin 35°$$

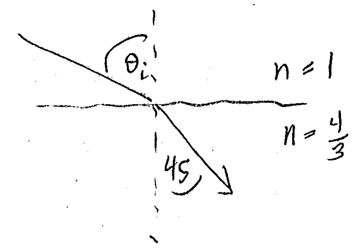


$$\Rightarrow \theta_r = 25.5°$$

$$\lambda_r = \frac{\lambda_i}{n_r} = \left(\frac{3}{4}\right)589\,nm = 442\,nm$$

Problem 35.11

use Snell's law w/ θ_r known



$$\sin\theta_i = \frac{n_r}{n_i}\sin\theta_r = \frac{4}{3}\sin 45$$

$$\theta_i = 70.5^\circ$$

want angle <u>above</u> <u>horizon</u>:

$$\theta = 90 - \theta_i = 19.5^\circ \text{ above horizon}$$

Problem 35.13

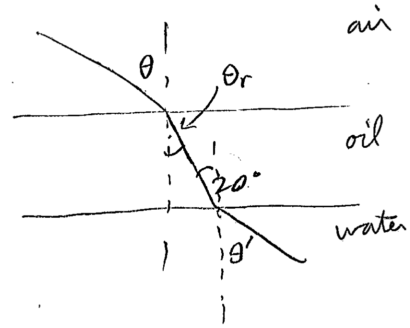
angle of reflection is same as angle of incidence, so get from Snell's law:

$$\sin\theta_i = \frac{n_r}{n_i}\sin\theta_r = \frac{1.52}{1.33}\sin 19.6^\circ$$

$$\theta_i = 22.5^\circ$$

$$\Rightarrow \theta_{ref} = 22.5^\circ$$

Problem 35.21



from geometry, $\theta_r = 20^\circ$ also

$$\Rightarrow \sin\theta = \frac{n_r}{n_i}\sin\theta_r = 1.48\sin 20^\circ$$

$$\Rightarrow \theta = 30.4^\circ$$

for water interface

$$\sin\theta' = \frac{n_{oil}}{n_{water}}\sin\theta_i = \frac{1.48}{1.33}\sin 20^\circ$$

$$\Rightarrow \theta' = 22.3^\circ$$

Problem 35.32

using fig 35.21 to get min and max n values

$n_{violet} = 1.47$; $n_{red} = 1.458$

find both angles of refraction ; difference gives angular spread

$$\sin\theta_{rv} = \frac{n_i}{n_{rv}} \sin\theta_i = \frac{\sin 30}{1.47}$$

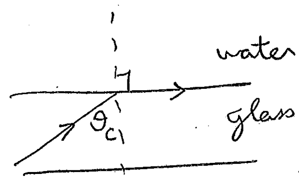
$$\Rightarrow \theta_{rv} = 19.885°$$

$$\sin\theta_{rr} = \frac{\sin 30}{1.458}$$

$$\Rightarrow \theta_{rr} = 20.059°$$

$$\Rightarrow \delta = \theta_{rr} - \theta_{rv} = 0.171°$$

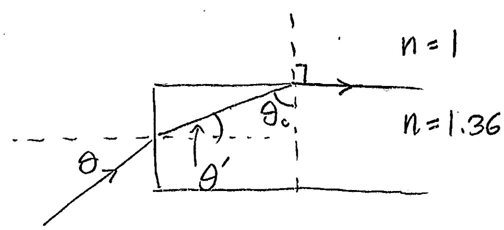
Problem 35.34



$$\sin\theta_c = \frac{n_r}{n_i} \cancel{\sin 90°}^{1} = \frac{1.33}{1.50}$$

$$\Rightarrow \theta_c = 62.5°$$

Problem 35.36



two reflections to deal with
(as shown)

first get θ_c :

$$\sin\theta_c = \frac{n_r}{n_i} \cancel{\sin 90}^{1} = \frac{1}{1.36}$$

$$\Rightarrow \theta_c = 47.3°$$

$\theta' = 90 - \theta_c = 42.7°$ angle of refraction for first incident :

$$\Rightarrow \sin\theta = \frac{n_r}{n_i} \sin\theta' = 1.36 \sin 42.7°$$

$$\Rightarrow \theta = 67.2°$$

Problem 36.7

(a) Since $f = \frac{R}{2}$ and is (−) for a convex mirror:

$$\frac{1}{p} + \frac{1}{q} = \frac{2}{R} \Rightarrow \frac{1}{30.0\text{cm}} + \frac{1}{q} = -\frac{2}{40.0\text{cm}}$$

$\Rightarrow q = -12.0$ cm (−) for virtual image "behind" mirror

$$M = -\frac{q}{p} = \frac{12.0}{30.0} = 0.400$$

(b) $$\frac{1}{60.0\text{cm}} + \frac{1}{q} = -\frac{2}{40.0\text{cm}} \Rightarrow q = -15.0\text{ cm}$$

$$M = \frac{-q}{p} = \frac{15.0}{60.0} = 0.250$$

(c) $M > 0 \Rightarrow$ upright images

Problem 36.13

(a) $M = -4 = \frac{-q}{p} \Rightarrow q = 4p$

real image and object are both on (+) side of mirror, larger image means $q > p$, so the distance given is $q - p$:

$q - p = 0.60\text{m} \Rightarrow 4p - p = 0.60\text{m} \Rightarrow p = 0.20\text{m}$ and $q = 0.80\text{m}$

$$\Rightarrow f = \frac{pq}{p+q} = \frac{0.16\text{m}^2}{1.0\text{m}} = 0.16\text{m}$$

(b) virtual image means $q < 0$, so 20.0 cm is $p + |q| = p - q$

since $M = \frac{1}{2} = \frac{-q}{p} \Rightarrow p = -2q$

$\Rightarrow p - q = -2q - q = 20.0\text{cm} \Rightarrow q = -6.67\text{cm}$ and $p = 13.3\text{cm}$

$$\Rightarrow \frac{1}{p} + \frac{1}{q} = \frac{2}{R} \Rightarrow R = 2\left(\frac{pq}{p+q}\right) = -26.7\text{cm}$$

Problem 36.20

$$\frac{n_i}{p} + \frac{n_r}{q} = \frac{n_r - n_i}{R} \quad \text{where } R \to \infty \quad \text{gives} \quad q = -p\left(\frac{n_r}{n_i}\right)$$

first find out where the top of the glass appears to be when looking through the water:

$$q_{top} = -12.0\text{ cm}\left(\frac{1.0}{1.33}\right) = -9.02\text{ cm} \quad \text{(below water surface)}$$

for the bottom, there are 2 steps; first find out where the bottom appears to be due to the glass:

$$q'_{bot} = -8.6\text{ cm}\left(\frac{1.33}{1.66}\right) = -6.41\text{ cm} \quad \text{(below top of glass)}$$

$\Rightarrow$ 18.41 cm below surface of water

now use this as an object to be refracted by the water:

$$q_{bot} = -18.41\text{ cm}\left(\frac{1.0}{1.33}\right) = -13.84\text{ cm} \quad \text{(below water surface)}$$

So the apparent thickness is $t = |q_{bot}| - |q_{top}| = 13.84\text{ cm} - 9.02\text{ cm}$

$\Rightarrow t = 4.82\text{ cm}$

Problem 36.22

$$\frac{n_i}{p} + \frac{n_r}{q} = \frac{n_r - n_i}{R}$$

a) $$\frac{1.0}{20.0\text{cm}} + \frac{1.50}{q} = \frac{0.5}{6.0\text{cm}} \Rightarrow q = 45.0\text{ cm}$$

b) $$\frac{1.0}{10.0\text{cm}} + \frac{1.50}{q} = \frac{0.5}{6.0\text{cm}} \Rightarrow q = -90.0\text{ cm}$$

c) $$\frac{1.0}{3.0\text{cm}} + \frac{1.50}{q} = \frac{0.5}{6.0\text{cm}} \Rightarrow q = -6.0\text{ cm}$$

Problem 36.27

(a) use lensmaker's eqn :

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.44-1)\left(\frac{1}{12.0\,cm} + \frac{1}{18.0\,cm}\right)$$

$\Rightarrow f = 16.4\,cm$

(b) since $R_2 < 0$ for both cases, the two inverses are additive, meaning we will get the same result when the lens is turned around :

$$\frac{1}{f} = (1.44-1)\left(\frac{1}{18.0\,cm} + \frac{1}{12.0\,cm}\right) = 16.4\,cm$$

Problem 36.29

(a) $\frac{1}{40.0\,cm} + \frac{1}{q} = \frac{1}{20.0\,cm} \Rightarrow q = 40.0\,cm$

$M = \frac{-q}{p} = \frac{-40.0}{40.0} = -1.0$ real inverted image beyond lens.

(b) $\frac{1}{20.0\,cm} + \frac{1}{q} = \frac{1}{20.0\,cm} \Rightarrow q \to \infty$

all rays emerge parallel; no image forms.

(c) $\frac{1}{10.0\,cm} + \frac{1}{q} = \frac{1}{20.0\,cm} \Rightarrow q = -20.0\,cm$

$M = \frac{20.0}{10.0} = 2.0$ virtual upright image in front of lens

Problem 36.31

$$M = 2 = -\frac{q}{p} \Rightarrow p = -\frac{q}{2} = -\frac{-2.84\,\text{cm}}{2} = 1.42\,\text{cm}$$

note signs are weird here b/c object is behind the lens from our perspective (where q is (-))

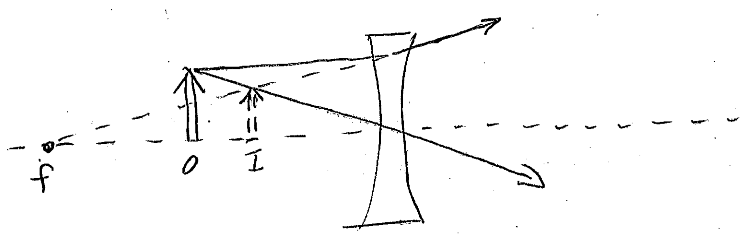
$$\Rightarrow f = \frac{pq}{p+q} = \frac{-2.84\,\text{cm}\,(1.42\,\cancel{\text{cm}})}{-1.42\,\cancel{\text{cm}}} = 2.84\,\text{cm}$$

Problem 36.33

(a) $\frac{1}{20.0\,\text{cm}} + \frac{1}{q} = \frac{-1}{32.0\,\text{cm}} \Rightarrow q = -12.3\,\text{cm}$

(also to the left of lens)

(b) $M = -\frac{q}{p} = \frac{12.3\,\cancel{\text{cm}}}{20.0\,\cancel{\text{cm}}} = 0.615$ (upright)



Problem 36.34

(b) $p + q = 3.0\,\text{m}$

$M = \frac{-1.80\,\text{m}}{0.024\,\text{m}} = -75.0$ (real inverted image)

$\Rightarrow \frac{-q}{p} = -75.0 \Rightarrow q = 75.0p$

$\Rightarrow p + 75.0p = 3.0\,\text{m} \Rightarrow p = \underline{0.0395\,\text{m}}$ and $q = 2.96\,\text{m}$

(a) so $f = \frac{pq}{p+q} = \frac{(0.0395\,\text{m})(2.96\,\text{m})}{3.0\,\text{m}} = 0.039\,\text{m}$