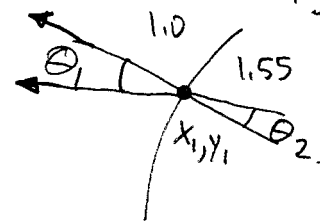


PHOTO HW1 - Fall 2008

1/3

1.

$$y = 0.25 \text{ incoming ray} \left. \begin{array}{l} \\ \\ \end{array} \right\} \begin{array}{l} (x-13.6)^2 + (0.25)^2 = 49 \\ (x-13.6)^2 + (y)^2 = 7^2 \end{array}$$



$$x^2 + 184.96 - 27.2x + .0625 - 49 = 0$$

$$x^2 - 27.2x + 136.0225 = 0 \quad Ax^2 + Bx + C = 0, \quad x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$x = 20.595534, \underline{6.604466} \quad (+/-)$$

intersection point : (6.604466, 0.25) (x_1, y_1)

incident vectors : $(-1, 0)$ $(6.604466 - 13.6, 0.25)$
 $(-6.995534, 0.25)$ (length $\equiv 7$)

unit vector

$$(-.999362, .035714)$$

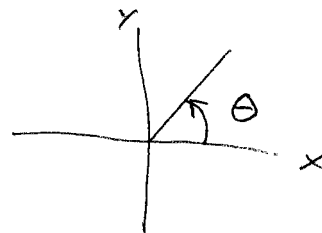
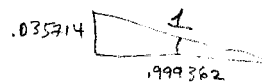
$$\vec{u}_1 \cdot \vec{u}_2 = \cos \theta = 0.999362$$

$$\theta_1 = \cos^{-1}(\downarrow) = \boxed{.035723 \text{ Rad}} \quad (2.0468^\circ)$$

Snell ; $\sin(0.035723) = 1.55 \sin \theta_2$

$$\sin \theta_2 = \frac{\sin(\uparrow)}{1.55} = .023042$$

$$\boxed{\theta_2 = .023044 \text{ Rad}} \quad (1.3203^\circ)$$



angle of interior ray = $\pi - \theta_1 + \pi + \theta_2$

$$= 6.270507 \text{ R}$$

$$= 6.270507 \text{ R} - 2\pi$$

$$\beta = -0.012679 \text{ R}$$

m , slope of line = $\tan(\beta) = -0.012679 \leftarrow$

eqn interior line = $\frac{y - 0.25}{x - 6.604466} = m$

$$y - 0.25 = mx - m \cdot 6.604466$$

$$y = mx - \underbrace{[m \cdot 6.604466]} + 0.25, \quad y = mx + b$$

$$b = .333741 \leftarrow$$

intersect with

$$(X-0)^2 + (Y-0)^2 = 7^2$$

$$Y = -0.012679 X + 0.333741$$

2/3

$$X^2 + m^2 X^2 + b^2 + 2mbX - 49 = 0$$

$$X^2 (1+m^2) + (2mb)X + (b^2-49) = 0$$

A B C

$$A = 1.000161$$

$$B = -0.008463$$

$$C = -48.888617$$

$$\text{rad} = 13.985206$$

$$\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$X_1 = 6.995710$$

$$X_2 = -6.987248$$

$$X = X_1, \quad Y = mX + b, \quad Y = 0.245039$$

$$(X_2, Y_2) = (6.995710, 0.245039)$$

$$(\text{angle} = 2.7326^\circ)$$

$$\theta_3 = 0.047692 \text{ R}$$

$$1.55 \sin \theta_3 = 1.0 \sin \theta_4$$

$$\sin \theta_4 = 1.55 \sin \theta_3 = 0.073961 \text{ R} (= 4.2377^\circ)$$

$$\text{ang-last-line} = \text{ang-radius} - \theta_4 = 0.035013 - 0.073961 \text{ (R)} = -0.038949$$

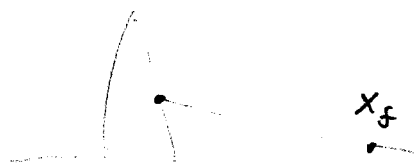
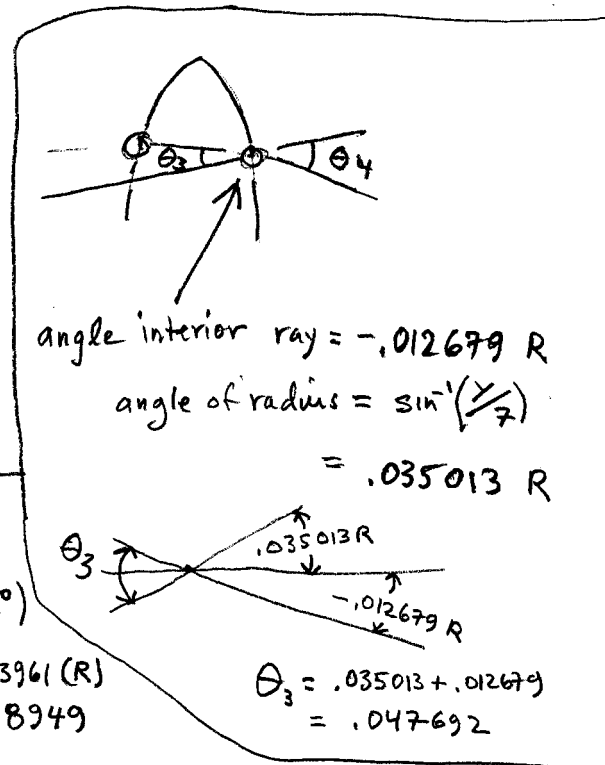
$$m = \tan(\text{ang-last-line}) = -0.038968$$

$$\frac{Y - 0.245039}{X - 6.995710} = m$$

(equation last line)

$$Y - 0.245039 = mX - m \cdot 6.995710$$

$$Y = mX + \underbrace{-m \cdot 6.995710 + 0.245039}_{b = 0.517650}$$



$$Y = mX + b \text{ @ } Y = 0$$

$$mX = -b$$

$$X = \frac{-b}{m}$$

$$X_f = \frac{-b}{m} = 13.283890$$

$$f = 13.283890 - 6.8$$

$$f = 6.483890$$

$$\text{R/T} = 6.48$$

$$\text{LMF} = 6.36$$

$$\frac{1}{f} \approx (n-1) \left[\frac{1}{r_1} + \frac{1}{r_2} \right] = 6.363636$$

Lens Maker's Equation

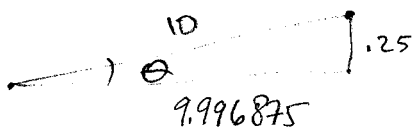
2. mirror ray trace:

$y = 0.25$, intersect w/ $(x-0)^2 + (y-0)^2 = 10^2$

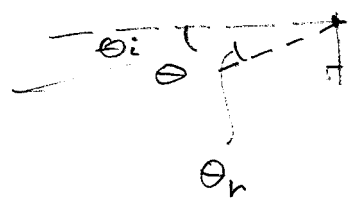
$x^2 + y^2 = 100$

$x^2 = [100 - 0.25^2]$, $x = \sqrt{100 - .25^2}$

$[x = 9.996875, y = 0.25]$ intsc pt.



$\theta = \sin^{-1} \left(\frac{.25}{10} \right) = .025003 \text{ R}$



$\theta_i = \theta = .025003 \text{ R}$

$\theta_r = \theta_i = .025003 \text{ R}$

ang refl ray $\nearrow = \theta + \theta_r = .050005$

$m = \tan(\text{ang refl ray } \nearrow) = .050047$

$\frac{y - .25}{x - 9.996875} = m$

$\frac{y - y_p}{x - x_p} = m$, $y - y_p = mx - mx_p$

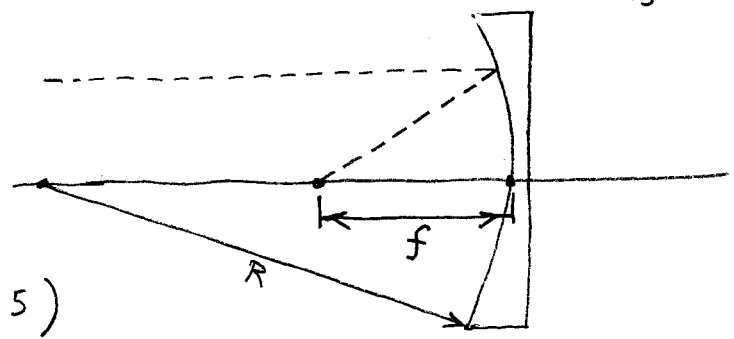
$y = \underbrace{mx - mx_p}_{b} + y_p$
 $b = -.250313$

$y = mx + b$, solve for $y = 0$

$mx = -b$

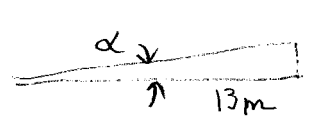
$x_f = \frac{-b}{m} = 5.001563$

$f = 10 - 5.0016 = 4.9984 \text{ (} R/2 = 5 \text{)}$



3. $f = 13 \text{ m}$, $d = 1 \text{ m}$ } (a) $f/\# = \frac{f}{d} = \frac{13}{1} = 13$

(b) $\alpha = \frac{1.22 \lambda}{d} = \frac{1.22 \times 550 \times 10^{-9} \text{ m}}{1} = \alpha = 6.71 \text{ e-}07$



$\frac{\delta}{13} = \tan(\alpha)$,

$\delta = 13 \tan \alpha$

$\delta = 8.723 \text{ e-}006$

$= 8.7 \mu\text{m}$