SOLUTION HW #2

(1) (a)

n' $\qquad$ $n = \frac{4}{3}$, $n' = 1$

USE $\dfrac{n}{s} + \dfrac{n'}{s'} = \dfrac{(n'-n)}{R}$

WITH $s = 5$ cm $\qquad R = -5$ cm

$$\frac{4/3}{5} + \frac{1}{s'} = \frac{\left(1-\frac{4}{3}\right)}{-5} \Rightarrow \frac{4}{15} + \frac{1}{s'} = \frac{1}{15} \Rightarrow s' = -5$$

THE IMAGE WILL APPEAR AT THE POSITION OF THE OBJECT

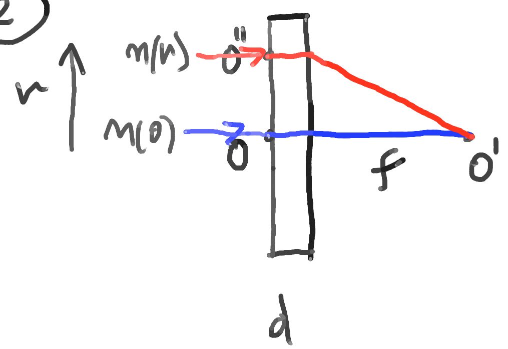
$$m = -\frac{s'}{s}\frac{n}{n'} = -(-1)\cdot 4/3 = +\frac{4}{3}$$

VIRTUAL IMAGE 4/3 TIMES BIGGER

(b) SAME AS (a) WITH $S = \frac{5}{2}$ cm

$$\frac{8}{15} + \frac{1}{s'} = \frac{1}{15} \Rightarrow s' = -\frac{15}{7}\text{ cm} \quad ; \quad m = \frac{\cancel{15}}{7}\,\frac{\cancel{2}}{8} \cdot \frac{4}{\cancel{3}} = \frac{8}{7}$$

(2)



IF f IS THE FOCAL LENGTH THE TIME OF TRAVEL O'' TO O' HAS TO BE THE SAME OF O TO O'

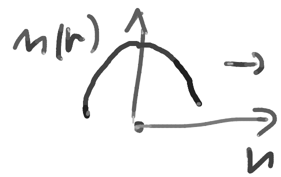
$$\Rightarrow \quad \frac{m(0)\,d}{c} + \frac{f}{c} = \frac{m(r)\,d}{c} + \frac{\sqrt{f^2 + r^2}}{c}$$

FOR $r \ll f$ WE HAVE

USE $\sqrt{1+\varepsilon^2} \sim 1 + \frac{\varepsilon^2}{2}$ (TAYLOR)

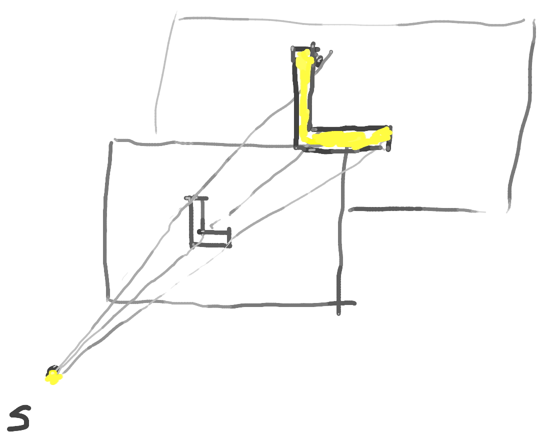
$$m(0)\, d + \cancel{f} = m(r)\, d + f\sqrt{1+\left(\frac{r}{f}\right)^2} \sim m(r)\, d + \cancel{f} + \frac{f}{2}\left(\frac{r}{f}\right)^2$$

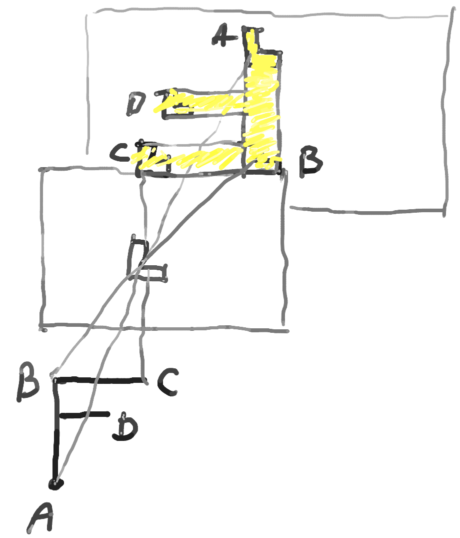
$$\Rightarrow \quad m(r) = m(0) - \frac{r^2}{2df}$$



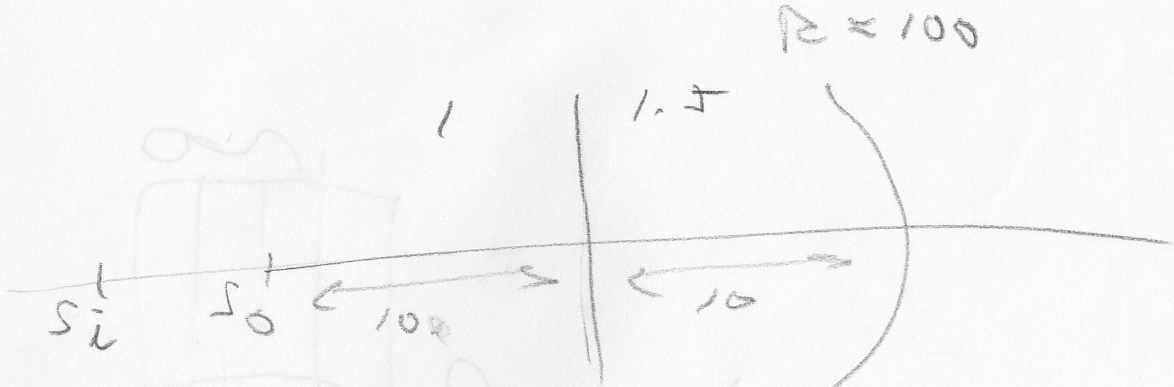
→ PARABOLIC GRADED INDEX

(3)





HW 2 #2



① $s_i' = -\frac{n_2}{n_1} s$, $n_1 = 1$, $n_2 = 1.5$

$= -1.5 \times 10$

$= -15$ mm (to left)

② $\left.\begin{array}{l} s_o' = 15 + 10 = 25 \\ n_1 = 1.5 \\ n_2 = 1 \end{array}\right\} \Rightarrow \frac{1.5}{25} + \frac{1}{s'} = \frac{1-1.5}{-100}$

$\Rightarrow \frac{1}{s'} = \frac{-0.5}{-100} - \frac{1.5}{25} = \frac{-6.5}{100}$

$\boxed{s_i' = -\frac{100}{6.5} = -15 \text{ mm}}$

if thin lens:

$\frac{1}{s_o} + \frac{1}{s_i} = \frac{n_2 - n_1}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$n_2 = 1.5$, $n_1 = 1$

$R_1 = \infty$, $R_2 = -100$

$\frac{1}{s_i} = \frac{0.5}{1}\left(0 - \frac{1}{-100}\right) - \frac{1}{10}$

$= \frac{1}{2} \times \frac{1}{100} - \frac{20}{200}$

$= -\frac{19}{200}$

$\Rightarrow s_i = -10$ mm