Unit 30 Homework Solution

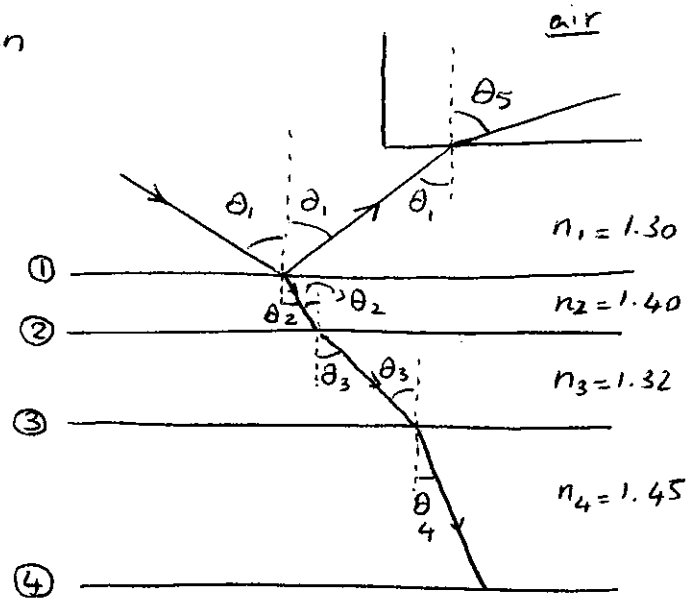
35-6

a) At the boundary between air and a medium 1:

$n_1 \sin\theta_1 = n_{air} \sin\theta_5$

$1.30 \sin 40.1^\circ = 1 \sin\theta_5$

$\Rightarrow \boxed{\theta_5 = 56.9^\circ}$



b) At ①:

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

②: $n_2 \sin\theta_2 = n_3 \sin\theta_3$

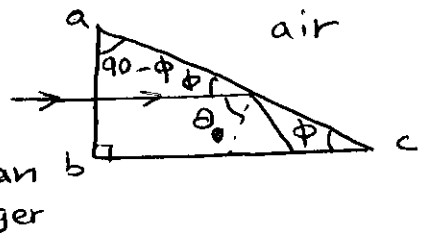
③: $n_3 \sin\theta_3 = n_4 \sin\theta_4$

$\therefore \quad n_1 \sin\theta_1 = n_4 \sin\theta_4 \Rightarrow 1.30 \sin 40.1^\circ = 1.45 \sin\theta_4$

$\Rightarrow \boxed{\theta_4 = 35.3^\circ}$

35-13

a) In order to have total internal reflection at face ac, θ should be ~~equal to~~ bigger than critical angle:



$n \sin\theta_c = n_{air} \sin 90^\circ \Rightarrow 1.52 \sin\theta_c = 1 \Rightarrow \theta_c = 41.1^\circ$

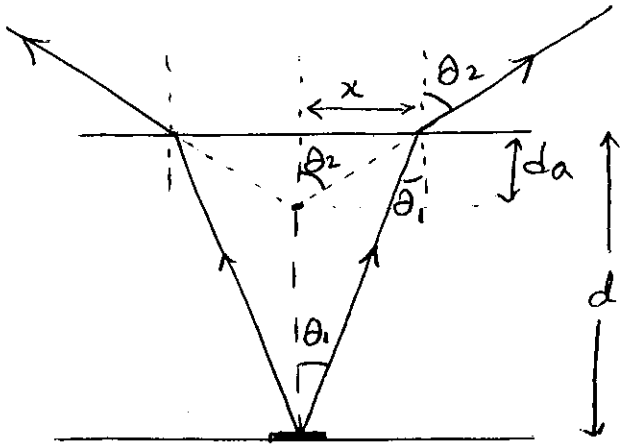
$\theta > 41.1^\circ \qquad \theta = 90 - \phi$

$90 - \phi > 41.1^\circ \Rightarrow \boxed{\phi < 48.9^\circ}$

b) $n \sin\theta_c = n_{water} \sin 90^\circ \Rightarrow 1.52 \sin\theta_c = 1.33 \Rightarrow \theta_c = 61.0^\circ$

$\theta > 61^\circ \Rightarrow 90 - \phi > 61^\circ \Rightarrow \boxed{\phi < 29^\circ}$

35 – 35



At the boundary:

$n \sin\theta_1 = 1 \sin\theta_2$ (Snell's law)

θ_1 and θ_2 are small angles:

$\sin\theta_1 \approx \tan\theta_1 = \frac{x}{d}$

$\sin\theta_2 \approx \tan\theta_2 = \frac{x}{d_a}$

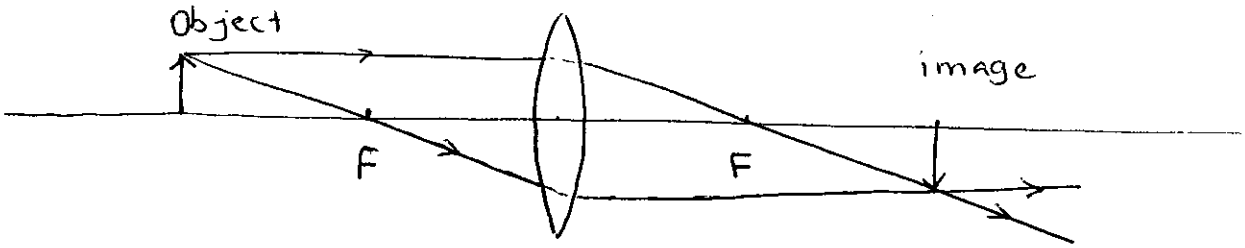
$\rightarrow n\frac{x}{d} = \frac{x}{d_a} \Rightarrow \boxed{d_a = \frac{d}{n}}$

35 – 44

a) Converging $\Rightarrow f = +10$, $\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20} \Rightarrow i = +20 \Rightarrow$ real

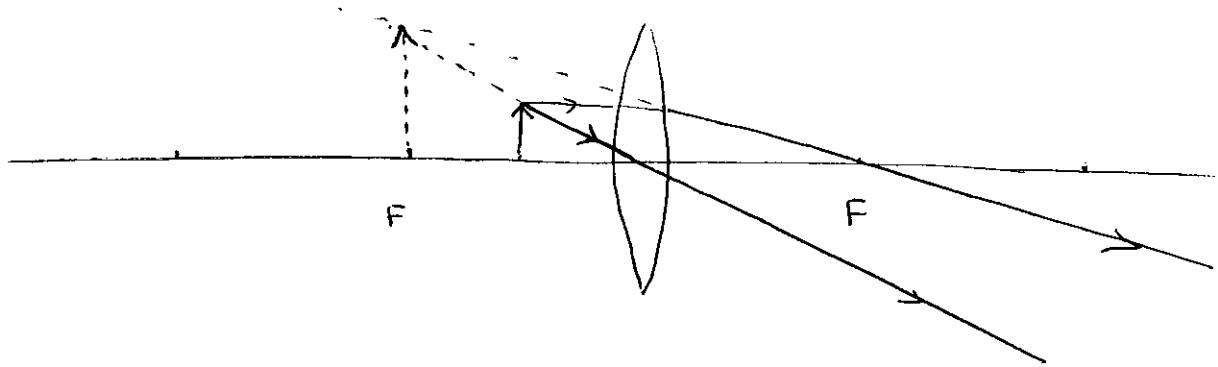
$m = -\frac{i}{o} = -\frac{20}{20} = -1 \Rightarrow$ inverted

Not enough info to find r_1, r_2, and n.



b) $f = +10 \Rightarrow$ type: C $\quad \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{10} - \frac{1}{5} = -\frac{1}{10} \Rightarrow i = -10$ cm

$\rightarrow$ virtual image, $m = -\frac{i}{o} = \frac{10}{5} = +2 \Rightarrow$ not inverted



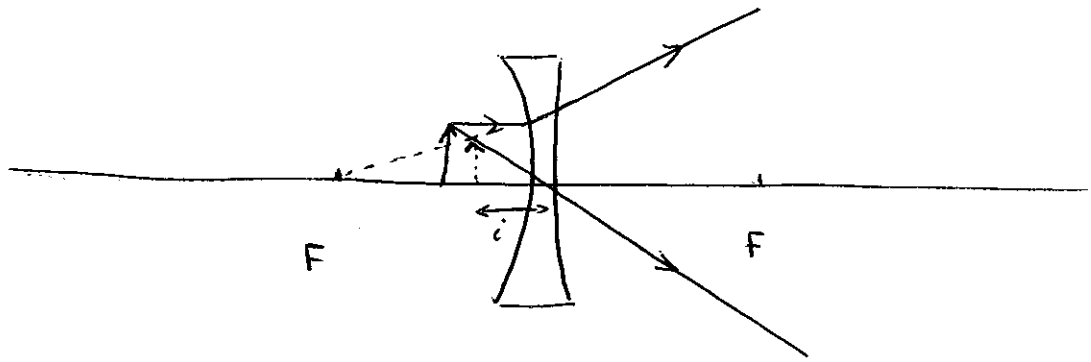
c) $m > 1.0 \Rightarrow$ type: C $\Rightarrow f = +10 \quad o = +5 \Rightarrow i = -10 \quad m = +2$

"Same as part b"

d) $m < 1.0$ and $0 < f \Rightarrow$ type: D $\Rightarrow f = -10$

$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-10} - \frac{1}{5} = -\frac{3}{10} \Rightarrow i = -\frac{10}{3}$ virtual

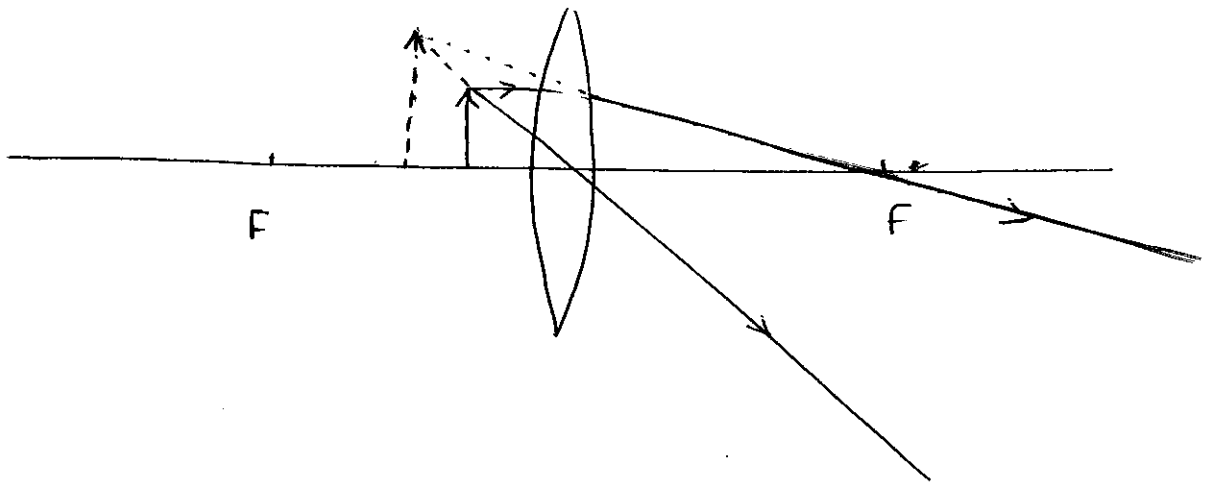
$m = -\frac{i}{o} = \frac{10/3}{5} = +\frac{2}{3}$ not inverted



e) $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = (1.5-1)\left(\frac{1}{30} - \frac{1}{-30}\right) \Rightarrow f = +30$

$\Rightarrow$ Type: C $\quad \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{30} - \frac{1}{10} = \frac{-2}{30} \Rightarrow i = -15$

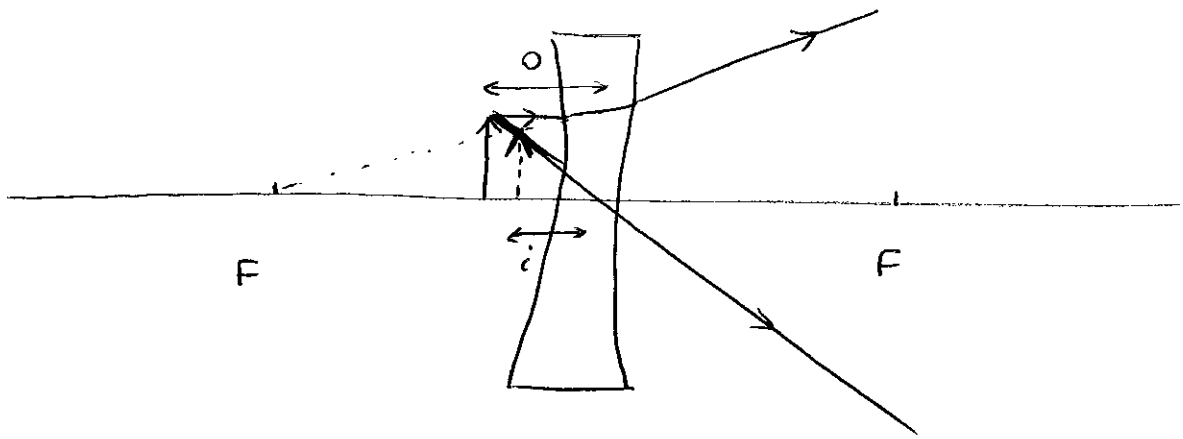
$m = -\frac{i}{o} = \frac{15}{10} = +1.5$ virtual, not inverted



f) $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = (0.5)\left(\frac{1}{-30} - \frac{1}{30}\right) \Rightarrow f = -30\text{ cm} \Rightarrow$ Type: D

$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-30} - \frac{1}{10} = -\frac{4}{30} \Rightarrow i = -7.5 \Rightarrow$ virtual

$m = -\frac{i}{o} = \frac{7.5}{10} = +0.75$ not inverted



g) $\frac{1}{f} = 0.5\left(\frac{1}{-30} - \frac{1}{-60}\right) \Rightarrow$ [illegible] $f = -120$ cm

$\Rightarrow$ Type : D $\quad \frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-120} - \frac{1}{10} \Rightarrow i = -\frac{120}{13}$

$m = -\frac{i}{o} = \frac{120/13}{10} = +\frac{12}{13} \Rightarrow$ Virtual and not inverted

graph is similar to part (f)

h) $m = +0.5 < 1$ (Not inverted) $\Rightarrow$ Type : D $\quad m = -\frac{i}{o} \Rightarrow +0.5 = -\frac{i}{10} \Rightarrow i = -5$

Virtual

$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{10} - \frac{1}{5} = -\frac{1}{10} \Rightarrow f = -10$ cm

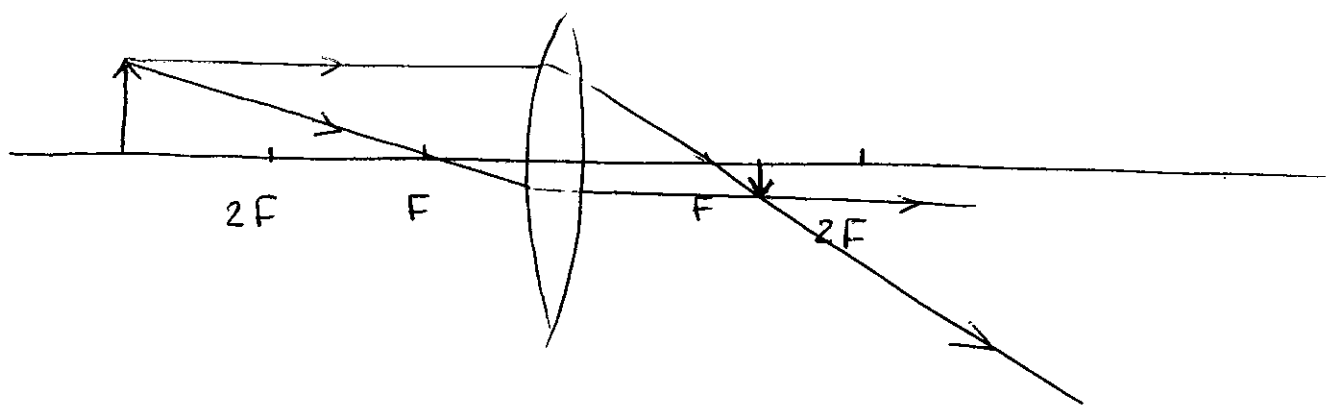
i) $m = -0.5 \Rightarrow$ inverted $\quad m = -\frac{i}{o} \Rightarrow -0.5 = -\frac{i}{10} \Rightarrow i = +5$ cm

$\Downarrow$

type : C <= real imag

$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{10} + \frac{1}{5} = \frac{3}{10}$

$f = +10/3$



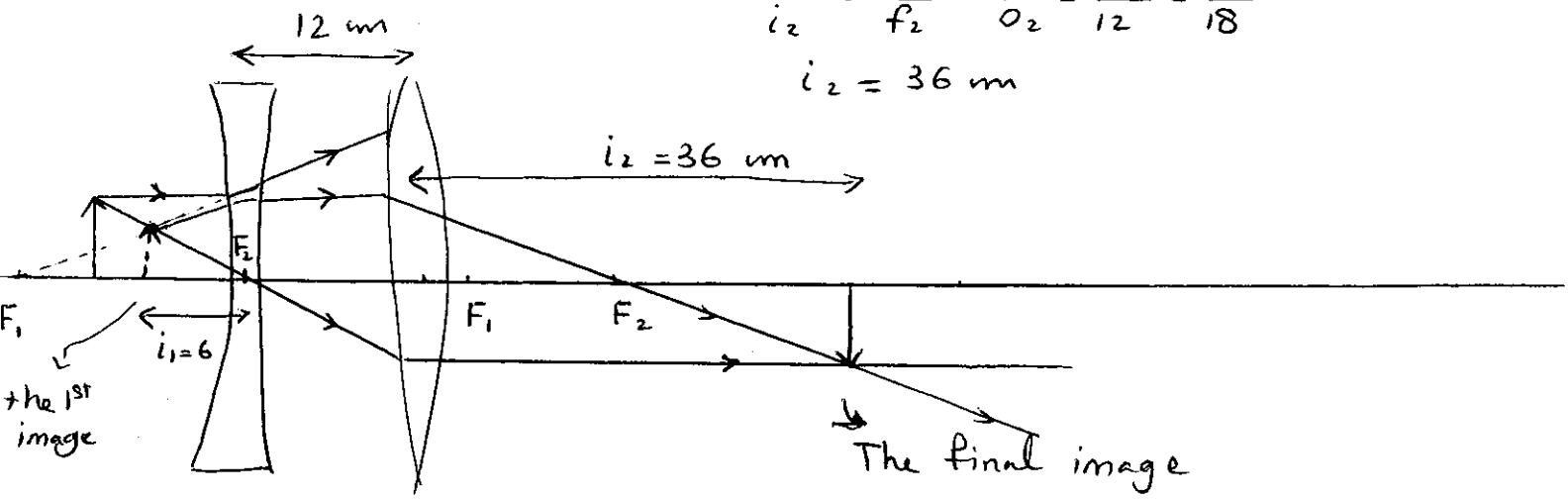
35–46 a) First image is formed by the diverging lens:

$$\frac{1}{i_1} = \frac{1}{f_1} - \frac{1}{o_1} = \frac{1}{-15} - \frac{1}{10} \Rightarrow \quad i = -6 \quad \text{(virtual)}$$

This image acts as an object for the second lens: $o_2 = 6 + 12 = 18\,cm$

$$\frac{1}{i_2} = \frac{1}{f_2} - \frac{1}{o_2} = \frac{1}{12} - \frac{1}{18}$$

$$i_2 = 36\ cm$$



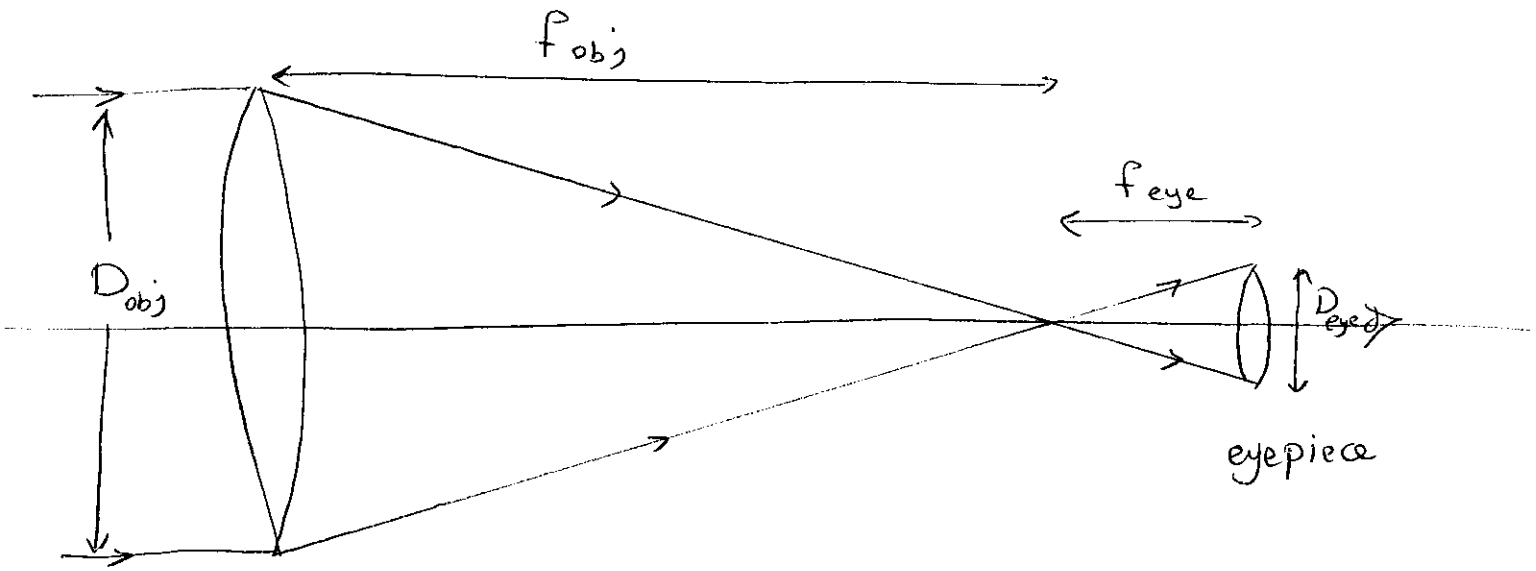
b) $$m_1 = -\frac{i_1}{o_1} = -\frac{-6}{10} = \frac{6}{10} \Rightarrow \frac{h_1'}{h} = \frac{6}{10} \Rightarrow h' = \left(\frac{6}{10}\right)(1\,cm) = 0.6\,cm$$

$$m_2 = -\frac{i_2}{o_2} = -\frac{36}{18} = -2 \Rightarrow \frac{h_2'}{h_1'} = -2 \Rightarrow h_2' = -2(0.6) = -1.2\,cm$$

c) Real

d) Image is inverted.

$$m_\theta = 36 \Rightarrow \frac{f_{obj}}{f_{eye}} = 36 \Rightarrow f_{obj} = 36\, f_{eye}$$



$$\frac{f_{obj}}{f_{eye}} = \frac{D_{obj}}{D_{eye}} = 36$$

$$\Rightarrow D_{eye} = \frac{D_{obj}}{36} = \frac{75}{36} = 2.1 \text{ mm}$$