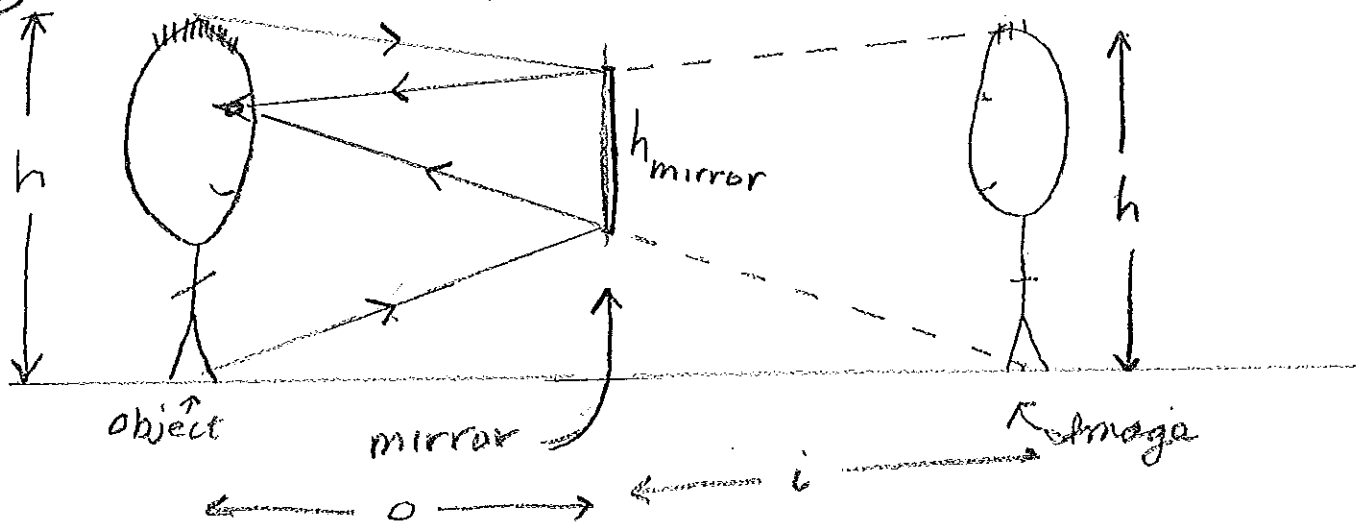
# Solutions to HWK 3 PHY234

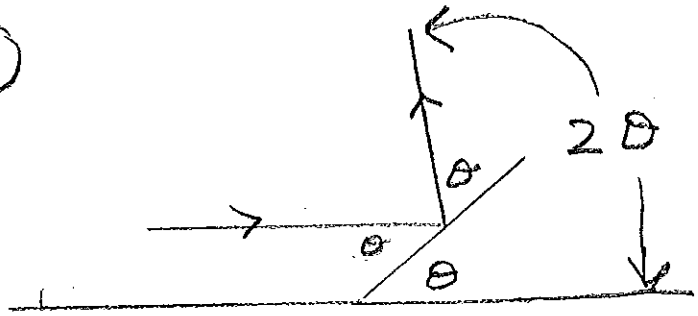
(1)



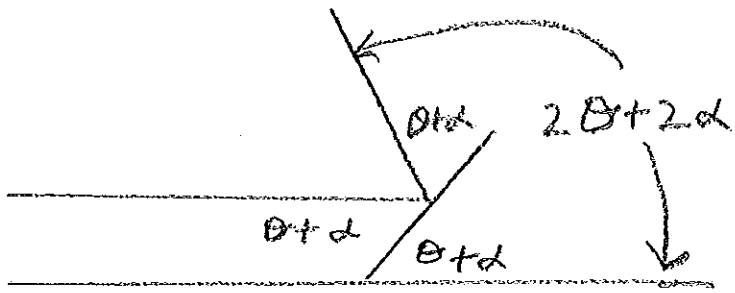

$$\frac{h_{mirror}}{h} = \frac{o}{o+i} \quad \text{but} \quad \boxed{o = i}$$

$$\frac{h_{mirror}}{h} = \frac{o}{2o} = \frac{1}{2} \Rightarrow \boxed{h_{mirror} = \frac{h}{2}} \quad \text{half your height}$$

(2)




The reflected beam is rotated $2\alpha$



(3) $m = 2.5 = -i/o$

and $f \simeq \frac{35}{2}$ cm

$i = (-2.5)\,o$

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$

$$\frac{1}{o} - \frac{1}{(2.5)o} = \frac{2}{35}$$

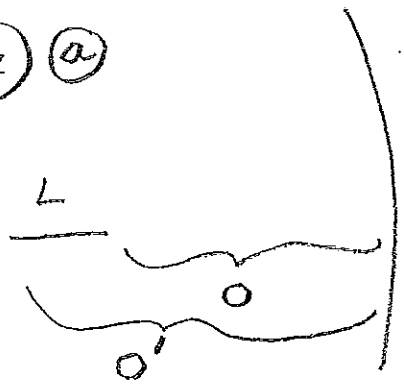
$$\frac{1}{o} - \frac{2}{(5)o} = \frac{2}{35}$$

$$\frac{1}{o}\left(1 - \frac{2}{5}\right) = \frac{2}{35}$$

$$\frac{1}{o}\left(\frac{3}{5}\right) = \frac{2}{35}$$

$$\boxed{o = \frac{21}{2}\text{ cm}}$$

(4) (a)




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

$$\frac{1}{o'} + \frac{1}{i'} = \frac{1}{f} \Rightarrow \frac{1}{i'} = \frac{1}{f} - \frac{1}{o'}$$

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$o' = o + L$

$\boxed{L \ll o}$

$o' - o = L$

$i - i' = L'$

$$\frac{1}{i'} - \frac{1}{i} = \frac{1}{o} - \frac{1}{o'}$$

$$\frac{i - i'}{i'i} = \frac{o' - o}{o'o}$$

$$\frac{L'}{i'i} = \frac{L}{o'o}$$

$$\frac{L'}{L} = \left(\frac{i'}{o'}\right)\left(\frac{i}{o}\right)$$

(4 cont) but since $\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$

$$1 + \frac{o}{i} = \frac{o}{f}$$

$$\frac{o}{i} = \frac{o}{f} - 1 = \frac{o-f}{f}$$

$$\frac{i}{o} = \frac{f}{o-f}$$

So

$$\frac{L'}{L} = \left(\frac{f}{o'-f}\right)\left(\frac{f}{o-f}\right) = \left(\frac{f}{o+L-f}\right)\left(\frac{f}{o-f}\right)$$

if $L \ll o$ then $o+L \simeq o$,

$$\frac{L'}{L} \simeq \left(\frac{f}{o-f}\right)\left(\frac{f}{o-f}\right) = \left(\frac{f}{o-f}\right)^2$$

$$\boxed{L' = L\left(\frac{f}{o-f}\right)^2}$$

(b) $m = \frac{i}{o} = \frac{f}{o-f}$ so $\boxed{\frac{L'}{L} = m^2}$

another way to derive this is to take differentials of

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$

$$-\frac{1}{o^2}\Delta o - \frac{1}{i^2}\Delta i = 0$$

$$\frac{L}{o^2} + \frac{L'}{i^2} = 0 \Rightarrow \left|\frac{L'}{L}\right| = \frac{i^2}{o^2} = m^2$$

(5)

a) $\frac{1}{10} + \frac{1}{i} = \frac{1}{20}$

$\frac{1}{i} = \frac{1}{20} - \frac{1}{10} = -\frac{1}{20}$

$i = -20\ cm$

$m = -\frac{i}{o} = -\frac{(-20)}{10} = 2$

$r = 40\ cm$

$i = -20\ cm$

$m = 2$

virtual image

b) $+1 = -\frac{i}{o} = \frac{-i}{10}$

$i = -10\ cm$

$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$

$\frac{1}{10} + \frac{1}{-10} = 0 = \frac{1}{f}$

$f = \infty$

$f = \infty$

$r = \infty$

$i = -10\ cm$

Flat mirror

virtual image

c) $\frac{1}{30} + \frac{1}{i} = \frac{1}{20}$

$\frac{1}{i} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$

$i = 60\ cm$

$m = -\frac{60}{30} = -2$

$r = 40\ cm$

$i = 60\ cm$

$m = -2$

real image

(5 cont.)

d) $-.5 = \frac{-i}{60}$

$i = 30\,cm$

$\frac{1}{60} + \frac{1}{30} = \frac{1}{f}$

$\frac{1}{20} = \frac{1}{f}$

$f = 20\,cm$

$f = 20\,cm$

$r \simeq 40\,cm$

$i = 30\,cm$

real image

e) $f = -20\,cm$

$\frac{1}{o} - \frac{1}{10} = -\frac{1}{20}$

$\frac{1}{o} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$

$o = 20\,cm$

$m = -\frac{(-10)}{20} = 1/2$

$f = -20\,cm$

$o = 20\,cm$

$m = 1/2$

virtual image

f) $.1 = -\frac{i}{o}$

$o = -10i$ ← Since $o > 0$

$\frac{1}{-10i} + \frac{1}{i} = \frac{-1}{20}$

$\frac{1}{i}\left(1 - \frac{1}{10}\right) = \frac{-1}{20}$

$\frac{1}{i} = \frac{-10}{9}\left(\frac{1}{20}\right)$

$i = -18\,cm$

$o = 180\,cm$

$f = -20\,cm$

$r = -40\,cm$

$i = -18\,cm$

$o = 180\,cm$

virtual image