44-13 $o = 150 \times 10^6\ Km = 1.5 \times 10^{11}\ m$

$h_o = 1.4 \times 10^9\ m$ $\qquad f = 0.27\ m$

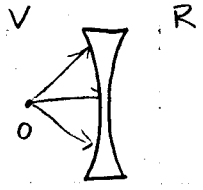
$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f} \Rightarrow \frac{1}{i} = \frac{1}{f} - \frac{1}{o}$$

$$i \approx f = 0.27\ m$$

$$|m| = \frac{i}{o} = 1.8 \times 10^{-12}$$

$$m = \frac{h_i}{h_o} i \Rightarrow h_i = m h_o = 2.5 \times 10^{-}$$

44-16



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

where $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

$$= (n-1)\left(\frac{-1}{r} - \frac{1}{r}\right)$$

$$= -\frac{2(n-1)}{r}$$

$o = r$

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

$$= -\frac{2(n-1)}{r} - \frac{1}{r}$$

$$= \left(\frac{-2n + 2 - 1}{r}\right)$$

$$\frac{1}{i} = \left(\frac{-2n + 1}{r}\right)$$

$$i = \frac{r}{1-2n}$$

$n > 1 \Rightarrow i$ is -ve

44-1

$m = 2.7 = \frac{-i}{o}$; $r = 35\,cm$

$i = -2.70$

$$\frac{1}{o} + \frac{1}{i} = \frac{2}{r}$$

$$\frac{1}{o} - \frac{1}{2.70} = \frac{2}{r}$$

$$\frac{1}{o}\left(1 - \frac{1}{2.7}\right) = \frac{2}{r}$$

$$\frac{r}{2}\left(1 - \frac{1}{2.7}\right) = o$$

$$\Rightarrow o = 11\,cm$$

063

44-11

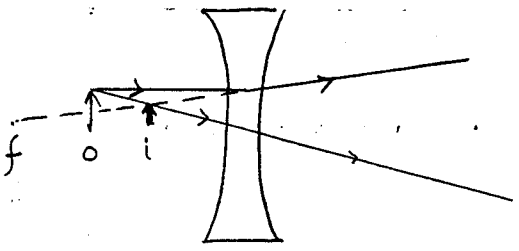
$o = 20\,cm$
$f = -30\,cm$

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

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

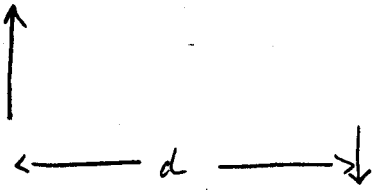
$$= \frac{1}{-30} - \frac{1}{20}$$

$\Rightarrow i = -12\,cm$ $\Rightarrow$ image is 12 cm from lens on left side (same as object) $\Rightarrow$ VIRTUAL



44-22

image is real, inverted, & minified
⇒ a converging lens is between object & image



$\Rightarrow |o| + |i| = 40\text{ cm}$ ①

$\frac{|i|}{|o|} = 0.5$ ②

② → ① $|o| + 0.5|o| = 40\text{ cm}$

$|o| = 26.7$ c

$\Rightarrow |i| = 13.3\text{ cm}$

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

$\frac{1}{26.7} + \frac{1}{13.3} = \frac{1}{f} \Rightarrow f = 9\text{ cm}$

44-25 $i + o = D$ (1) $\quad i \& o$ both +ve

$\frac{1}{i} + \frac{1}{o} = \frac{1}{f}$ (2)

there must be 2 sol'ns for i, o that satisfy both equations

(1) $\Rightarrow \quad o = D - i$

$\rightarrow$ (2) $\rightarrow \quad \frac{1}{i} + \frac{1}{D-i} = \frac{1}{f}$

$$\frac{D - i + i}{i(D-i)} = \frac{1}{f}$$

$$fD = iD - i^2$$

$$i^2 - iD + fD = 0$$

$$\Rightarrow \quad i = \frac{D \pm \sqrt{D^2 - 4fD}}{2}$$

$$= \frac{D}{2} \pm \frac{\sqrt{D(D-4f)}}{2}$$

$\Rightarrow$ 2 positions are SEPARATED by $\sqrt{D(D-4f)}$

for each position, $m = \frac{i}{o}$ & image size = m. obj. size

so ratio of image sizes $= \frac{m_1}{m_2}$

$$o_1 = D - \frac{D}{2} - \frac{\sqrt{D(D-4f)}}{2}$$

$$= \frac{D}{2} - \frac{\sqrt{D(D-4f)}}{2}$$

$$= i_2$$

$$= \frac{i_1}{o_1} \frac{o_2}{i_2}$$

$$= \frac{i_1^2}{i_2^2}$$

$$o_2 = D - \frac{D}{2} + \frac{\sqrt{D(D-4f)}}{2}$$

$$= \frac{D}{2} + \frac{\sqrt{D(D-4f)}}{2}$$

$$= i_1$$

$$= \frac{\left(D + \sqrt{D(D-4f)}\right)^2}{\left(D - \sqrt{D(D-4f)}\right)^2}$$

$$= \frac{(D+\alpha)^2}{(D-\alpha)^2}$$