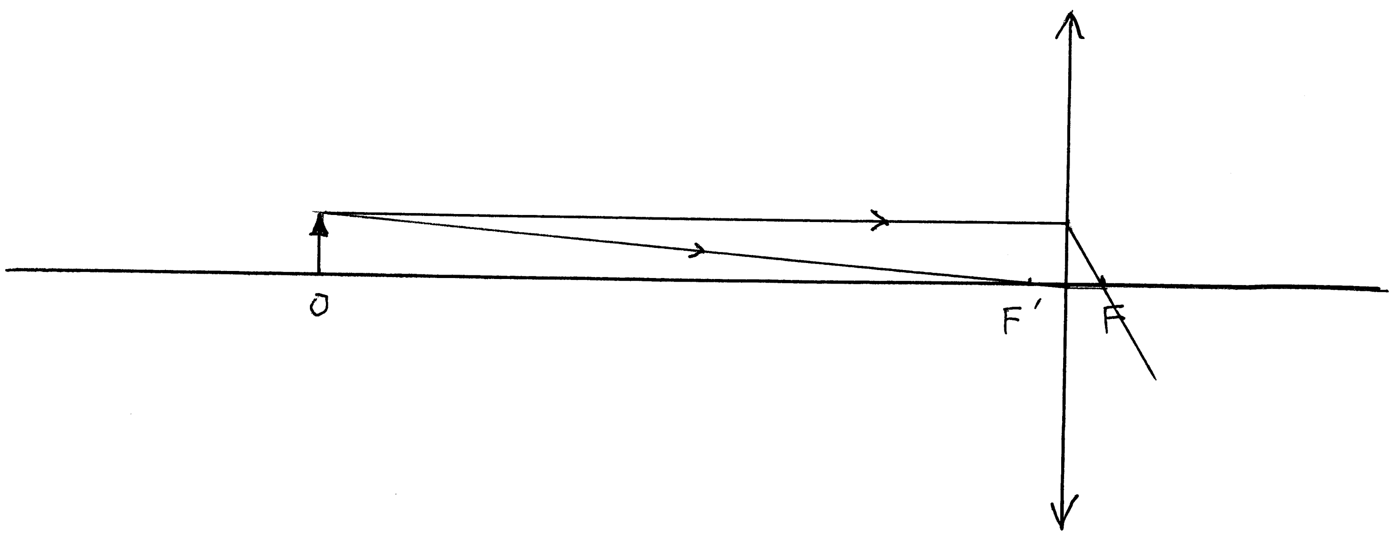
e.g. 33-2.



$f = 5.00$ cm.

$d_o = 1.00$ m $= 100$ cm.

$h_o = 7.6$ cm.

a) find: d_i. $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$.

$$d_i = \frac{d_o \cdot f}{d_o - f} = \frac{100 \times 5}{100 - 5} = 5.26 \text{ cm}.$$

b) size. h_i

$$m = -\frac{d_i}{d_o} = -\frac{5.26}{100} = -0.0526 = \frac{h_i}{h_o}.$$

$$h_i = m \cdot h_o = -0.0526 \times 7.6 = -0.40 \text{ cm}.$$

(The figure in the textbook is not to scale).

e.g. 33-2.

$f = 15\,cm$.

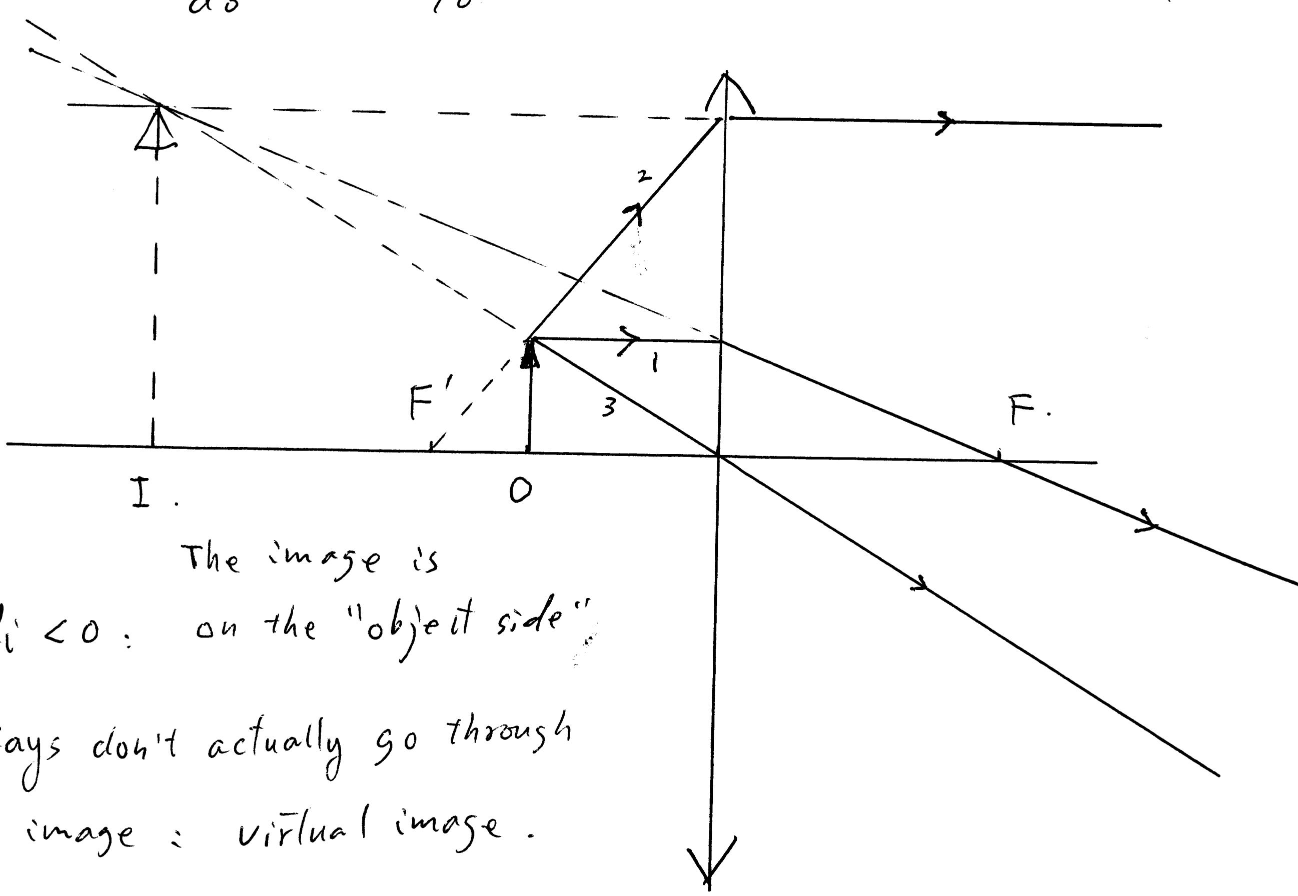
$d_o = 10\,cm$.

find: d_i, m.

$$\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}, \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o - f}{f\,d_o}$$

$$d_i = \frac{f \cdot d_o}{d_o - f} = \frac{10 \times 15}{10 - 15} = \frac{150}{-5} = -30\,cm.$$

$$m = -\frac{d_i}{d_o} = -\frac{-30}{10} = 3. \quad \text{(upright, larger)}$$



The image is

$d_i < 0$: on the "object side"

Rays don't actually go through the image: virtual image.

$m > 0$: upright.

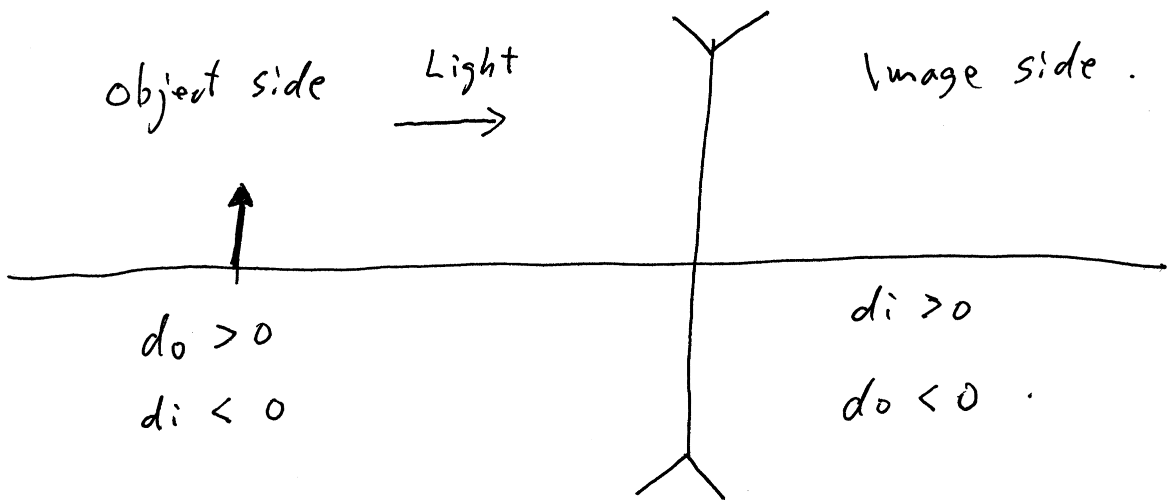
e.g. 33-4. Diverging Lens

$f = -25$ cm (Diverging means $f < 0$)

$d_i = -20$ cm (virtual image).

Find $d_o = ?$

How do we know $d_i = -20$ cm, NOT $+20$ cm ?



virtual image: emerging light rays do not cross each other (but their extensions do).

So the image must be on the object side.
$d_i < 0$.

Equation: $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$.

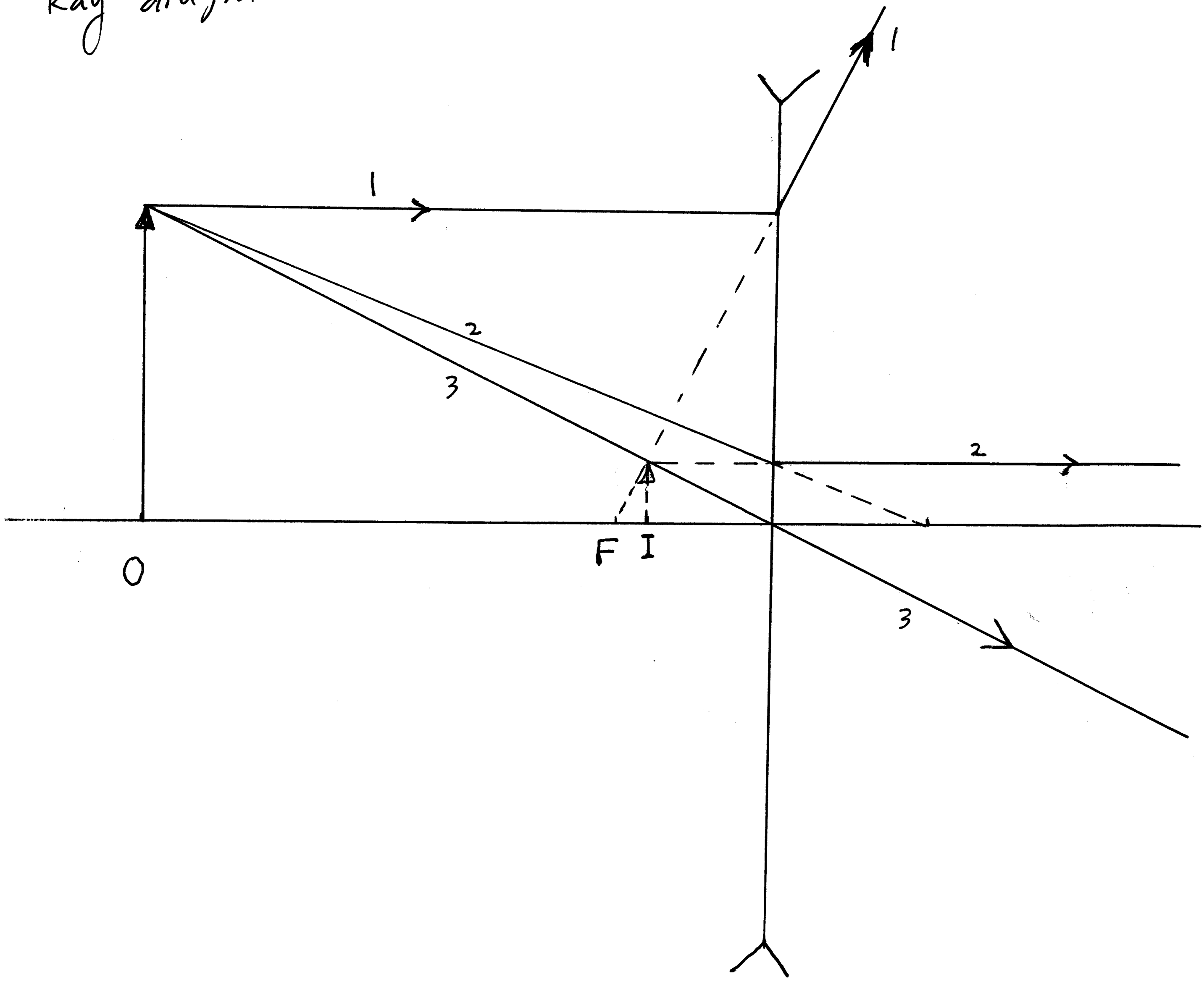
$$d_o = \frac{d_i \cdot f}{d_i - f} = \frac{(-20)(-25)}{(-20)-(-25)} = \frac{500}{5} = 100 \text{ cm}.$$

(positive d_o, on the object side)

$$m = -\frac{d_i}{d_o} = -\frac{-20}{100} = 0.20$$

up right, smaller image.

Ray diagram.

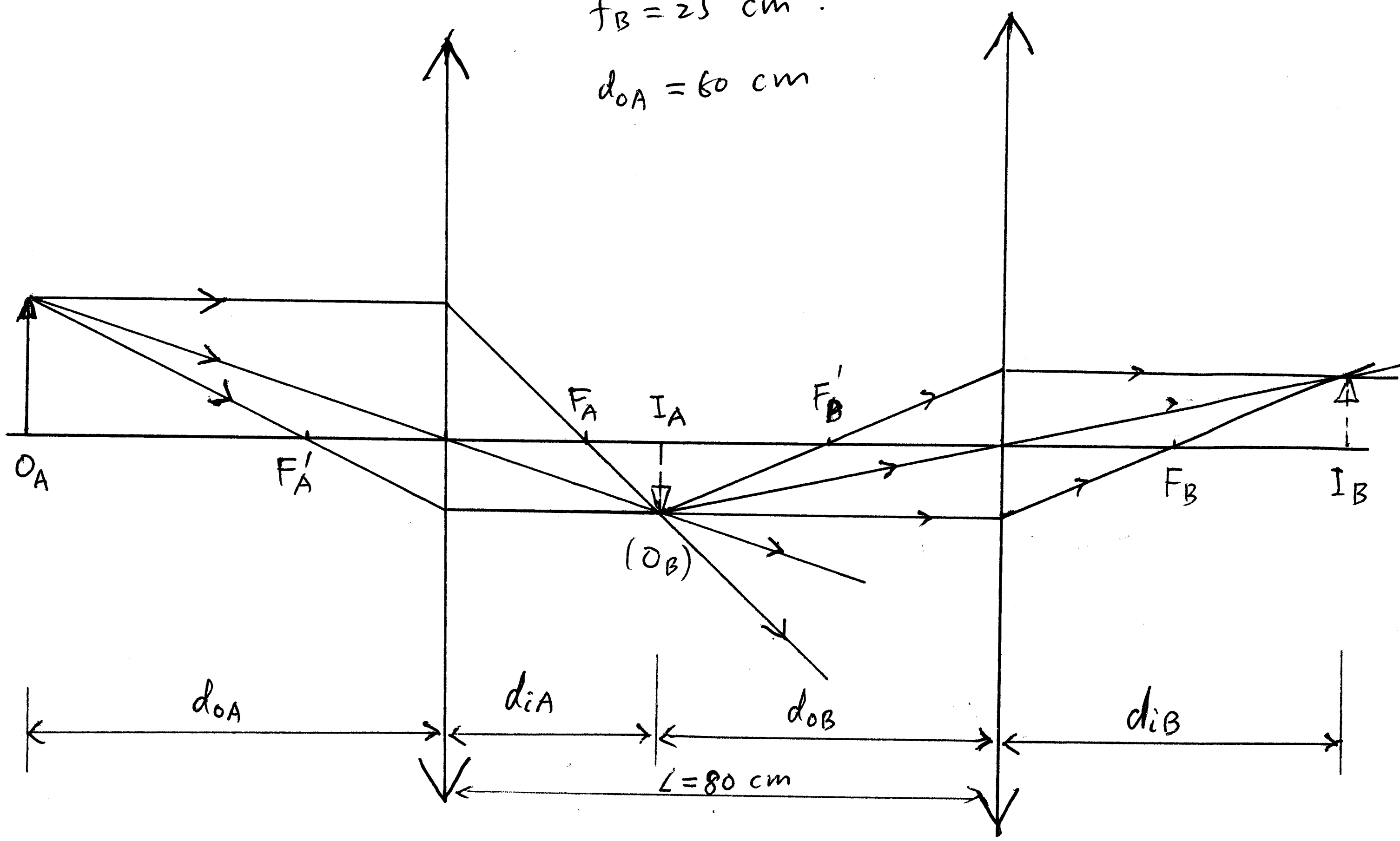


e.g. 33-5 .

A 2-lens system . $f_A = 20$ cm

$f_B = 25$ cm .

$d_{oA} = 60$ cm



$$d_{iA} = \frac{d_{oA} \cdot f_A}{d_{oA} - f_A} = \frac{60 \times 20}{60 - 20} = 30 \text{ cm}.$$

$$d_{oB} = 80 - 30 = 50 \text{ cm}.$$

$$d_{iB} = \frac{d_{oB}\, f_B}{d_{oB} - f_B} = \frac{50 \times 25}{50 - 25} = \text{[redacted]}\ \frac{1250}{25} = 50 \text{ cm}.$$

$$m = m_A \cdot m_B = \left(-\frac{d_{iA}}{d_{oA}}\right)\left(-\frac{d_{iB}}{d_{oB}}\right) = \left(-\frac{30}{60}\right)\left(-\frac{50}{50}\right) = 0.5.$$

Note: $m_B = -1$. — 1:1 image (upside down, same size as object).

This occurs when $d_i = d_o = 2f$.

e.g. 33-12. Farsighted eye. [Need to "bring" the object from 25 cm to 100 cm as an image]

$d_o = 25$ cm

$d_i = -100$ cm. (image on the object side, so "−")

$f = ?$

$$\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}.$$

$$f = \frac{d_i d_o}{d_i + d_o} = \frac{(-100)(25)}{(-100)+25} = \frac{-2500}{-75} = 33.3 \text{ cm}$$
$$= 0.333 \text{ m}.$$

Power: $P = \frac{1}{f} = +3.0$ D.

---

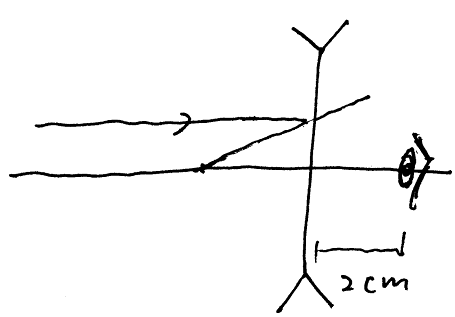
e.g. 33-13. $f_p = 17$ cm near sighted.

$n_p = 12$ cm. (reading distance is too short)

Need to "bring" the object from ∞ to 17 cm as an image.

$d_o = \infty$, $d_i = -17$ cm

for a contact lens.



Now: $d_i = -(17-2) = -15$ cm.

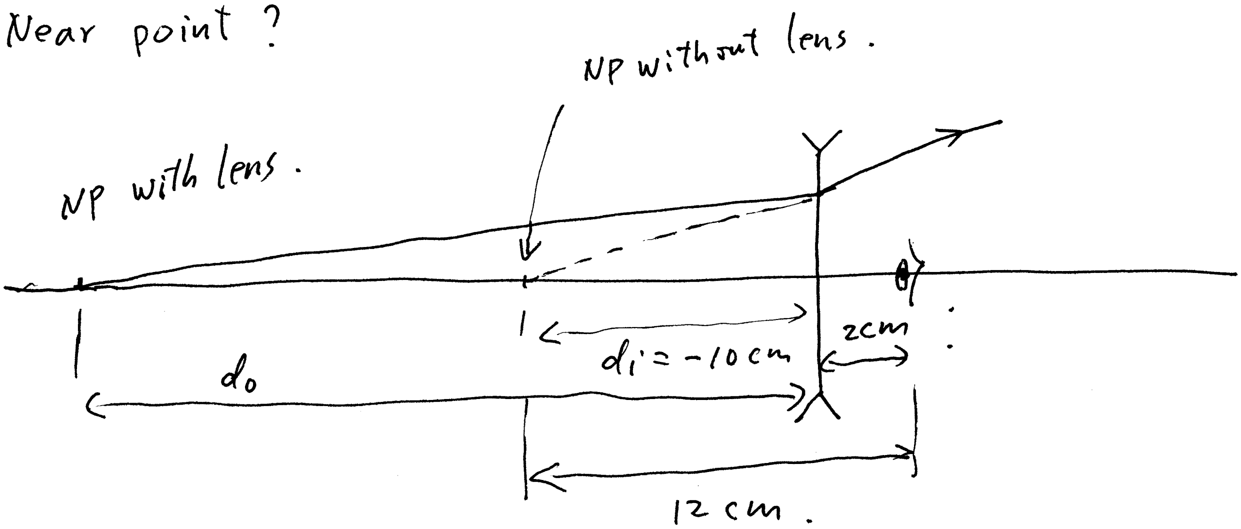
(sign of d_i: negative

$\because$ Image is on object side.

$f = d_i = -15\text{ cm}.$ $\left(\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i},\ d_o = \infty \right)$.

$P = \frac{1}{f} = \frac{1}{-0.15} = -6.7D$.

Near point ?



$d_i = -10\text{ cm},\quad f = -15\text{ cm}.\quad d_o = ?$

$$d_o = \frac{d_i f}{d_i - f} = \frac{(-10)(-15)}{(-10)-(-15)} = \frac{150}{5} = 30\text{ cm}$$

↑ np with glasses.

If it's a contact lens.

Find f: $d_o = \infty$, $d_i = -17$ cm.

$f = d_i = -17\text{ cm} = -0.17\text{ m}.$

$P = \frac{1}{f} = -5.9\text{ D}.$

NP with contact: $f = -17$ cm, $d_i = -12$ cm

$$np = d_o = \frac{d_i f}{d_i - f} = \frac{(-12)(-17)}{(-12)-(-17)} = \frac{204}{5} = 41\text{ cm}.$$

↖ too far!

e.g. 33-14.

$f = 8$ cm.

a). relax. $d_i = \infty$.

$$m = \frac{N}{f} = \frac{25}{8} \approx 3X$$

b). at NP. $N = 25$ cm.

$$m = \frac{N}{f} + 1 \approx 4X$$

(NOT required).

* e.g. 33-16. $m_e = 10$, $m_o = 50$. $\ell = 17$.

a). $m = m_e m_o = 10 \times 50 = 500X$

b). f_e, f_o.

$$m_e = \frac{N}{f_e} =$$

$$f_e = \frac{N}{m_e} = \frac{25}{10} = 2.5 \text{ cm}.$$

$$m_o = \frac{\ell - f_e}{d_o}.$$

$$d_o = \frac{\ell - f_e}{m_o} = \frac{17 - 2.5}{50} = 0.29 \text{ cm}$$

$$d_i = \ell - f_e = 17 - 2.5 = 14.5 \text{ cm}.$$

$$\frac{1}{f_o} = \frac{1}{d_i} + \frac{1}{d_o} \qquad f_o = \frac{d_i \times d_o}{d_i + d_o}$$

$$= \frac{14.5 \times 0.29}{14.5 + 0.29} \cancel{= 3.52 \text{ cm}}$$

$$= 0.28 \text{ cm}.$$

c) $d_o \approx f_o$

$= 0.29$ cm.