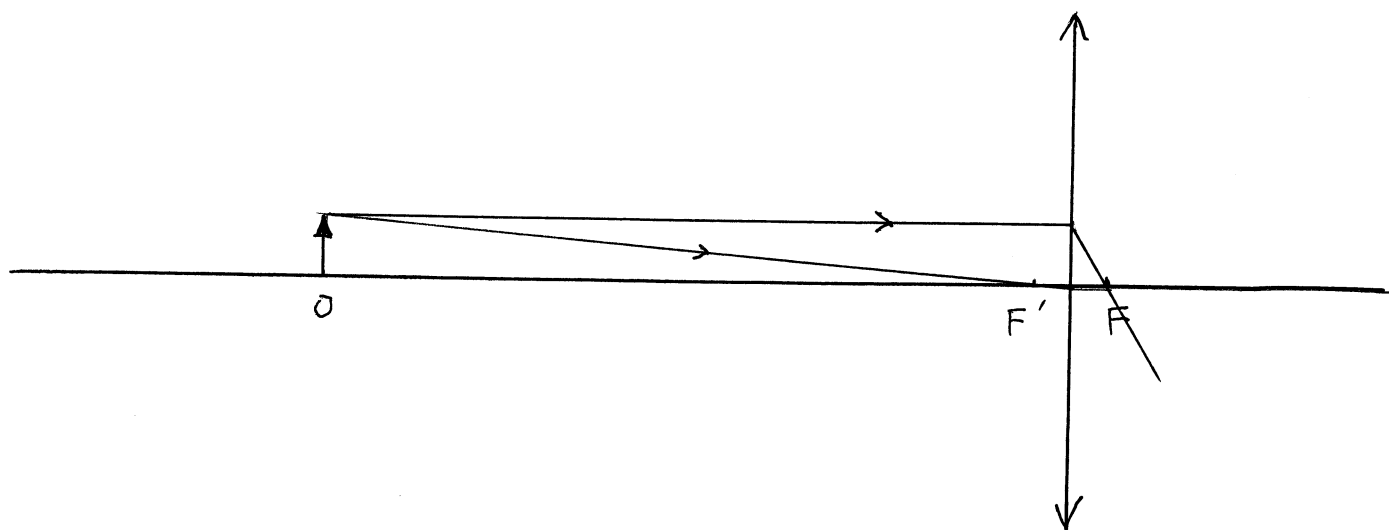


e.g. 33-2.



$$f = 5.00 \text{ cm.}$$

$$d_o = 7.00 \text{ m} = 100 \text{ cm.}$$

$$h_o = 7.6 \text{ cm.}$$

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.

$$f = 15 \text{ cm.}$$

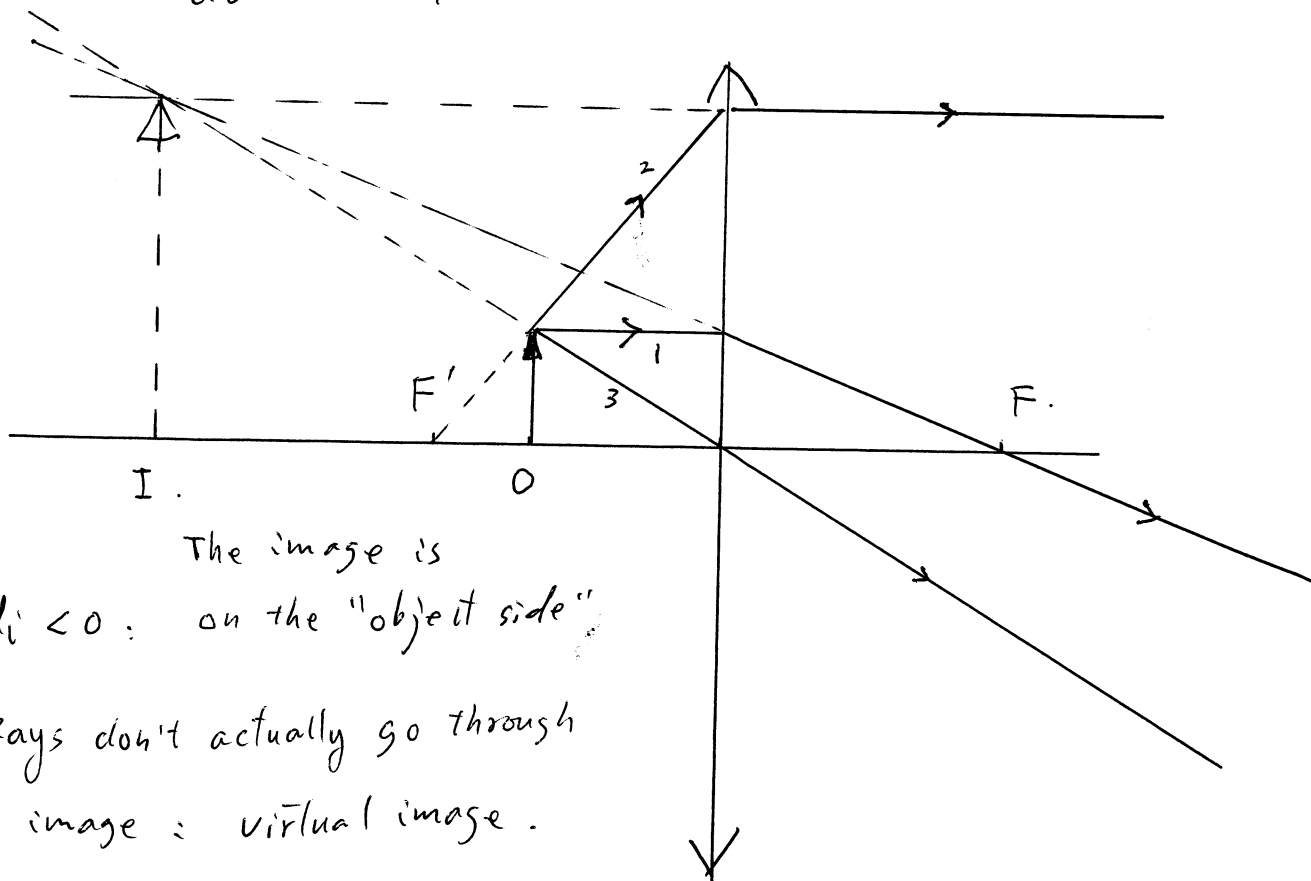
$$d_o = 10 \text{ cm.}$$

find: d_i , m .

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

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

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



The image is

 $d_i < 0$: on the "object side"Rays don't actually go through
the image: virtual image. $m > 0$: up right.

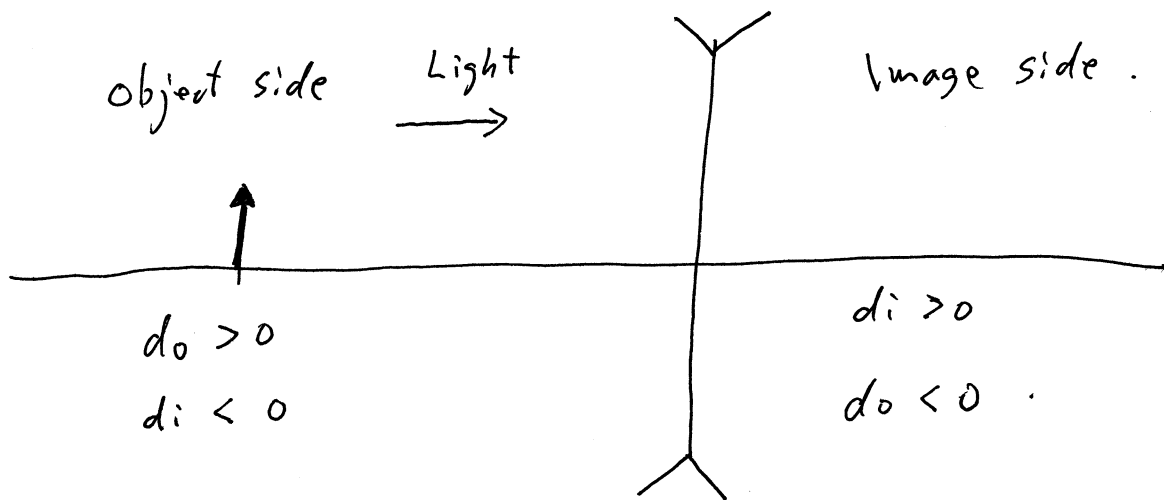
e.g. 33-4. Diverging Lens

$$f = -25 \text{ cm} \quad (\text{Diverging means } f < 0)$$

$$d_i = -20 \text{ cm} \quad (\text{virtual image})$$

Find $d_o = ?$

How do we know $d_i = -20 \text{ cm}$, NOT $+20 \text{ cm}$?



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's: $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$

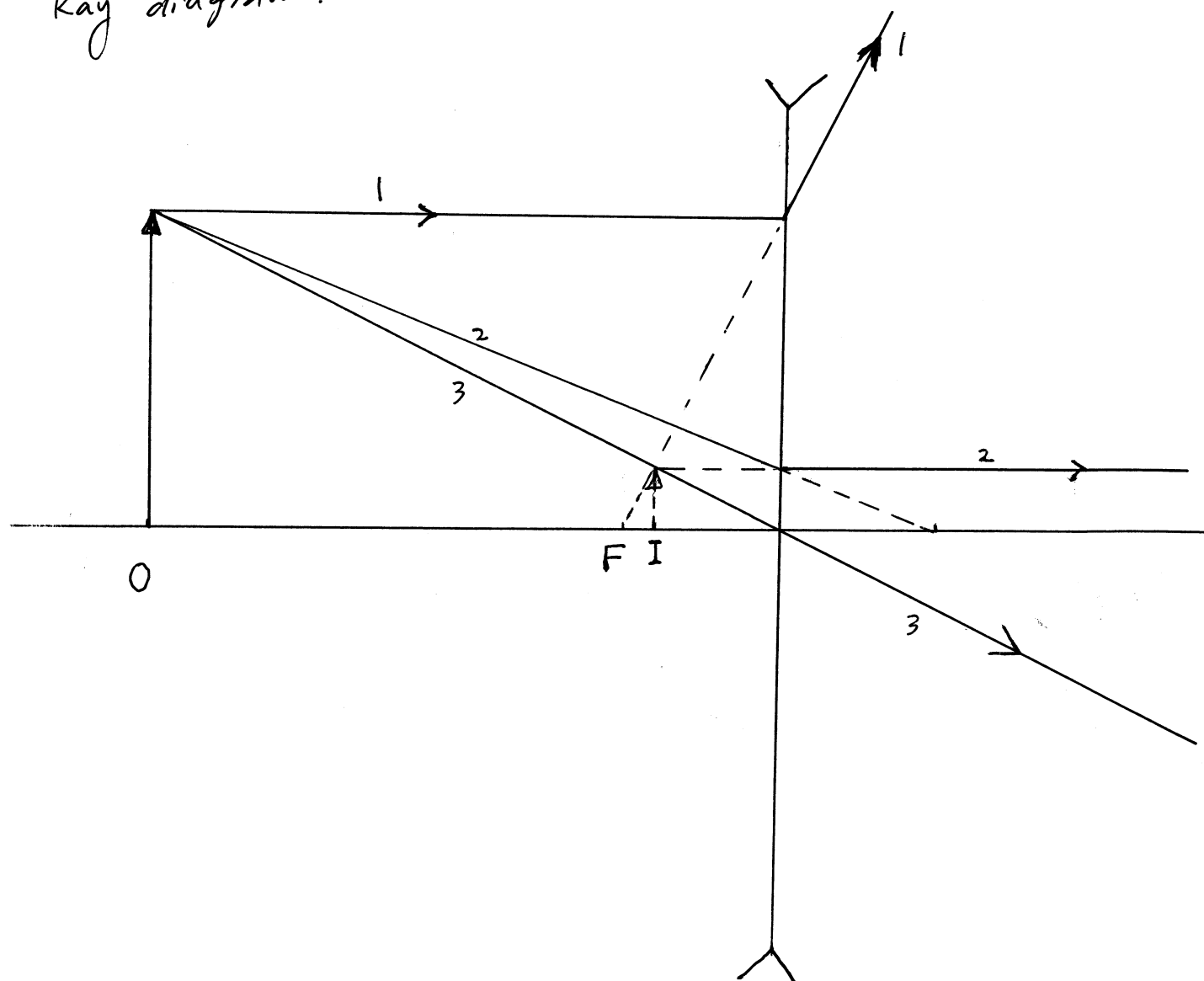
$$d_o = \frac{d_i \cdot f}{d_i - f} = \frac{(-20)(-25)}{(-20) - (-25)} = \frac{500}{5} = 100 \text{ cm}$$

(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.

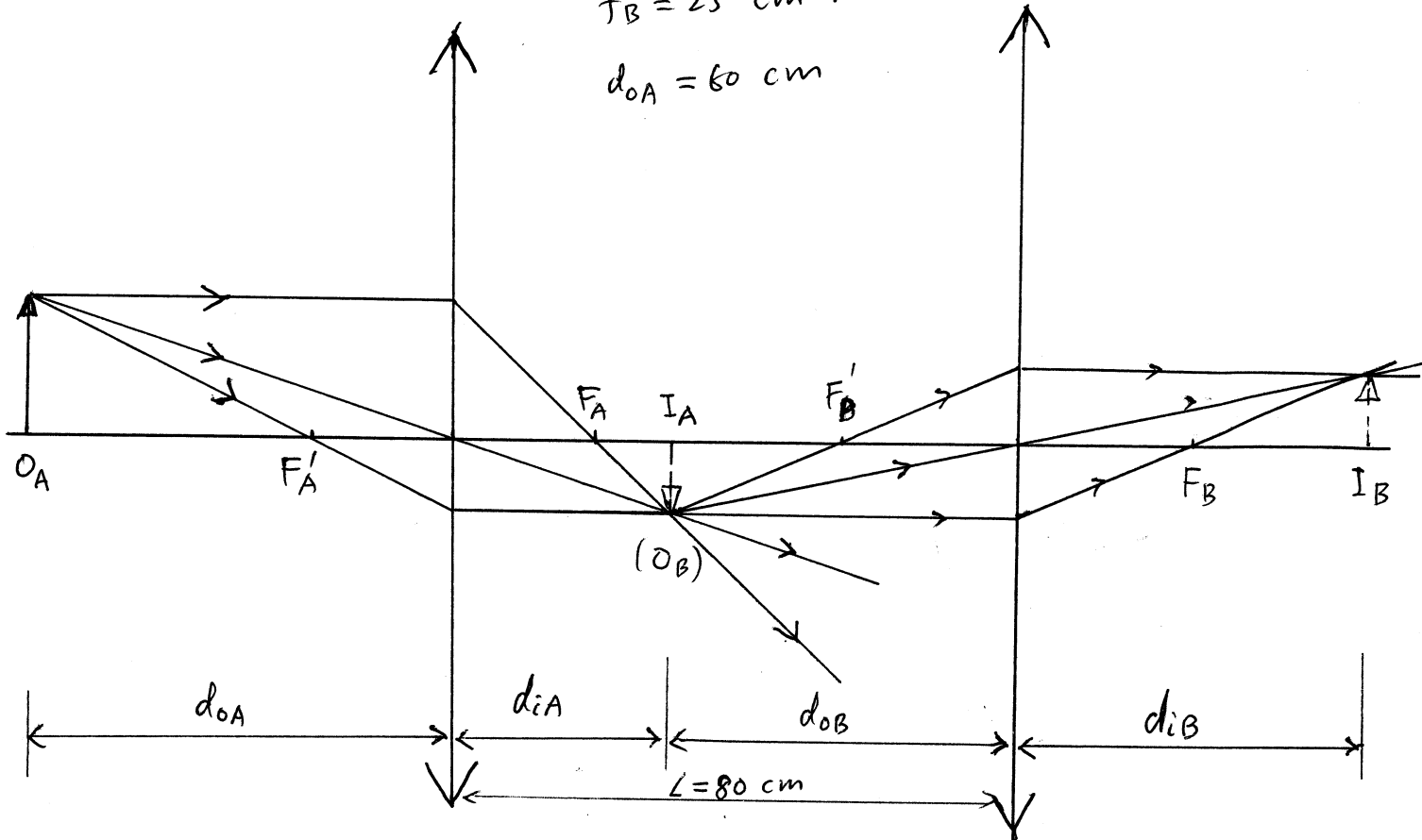
25-5

A 2-lens system

$$f_A = 20 \text{ cm}$$

$$f_B = 25 \text{ cm}$$

$$d_{oA} = 60 \text{ cm}$$



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

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

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

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

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. 25-6
 [Need to "bring" the object
 from 25 cm to 100 cm as an image]

$$d_o = 25 \text{ cm}$$

$$d_i = -100 \text{ cm} . \quad (\text{image on the object side, so "-"})$$

$$f = ?$$

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

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

$$= 0.333 \text{ m} .$$

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

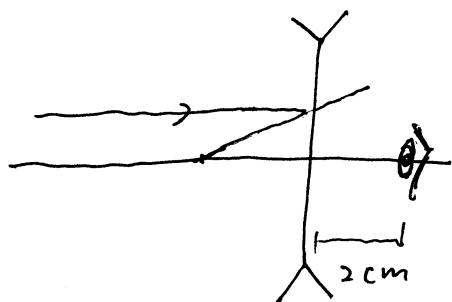
e.g. 33-13. $f_p = 17 \text{ cm}$ nearsighted .

$n_p = 12 \text{ cm}$. (reading distance is too short)

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

$$d_o = \infty , \quad \underline{d_i = -17 \text{ cm}}$$

for a contact lens .



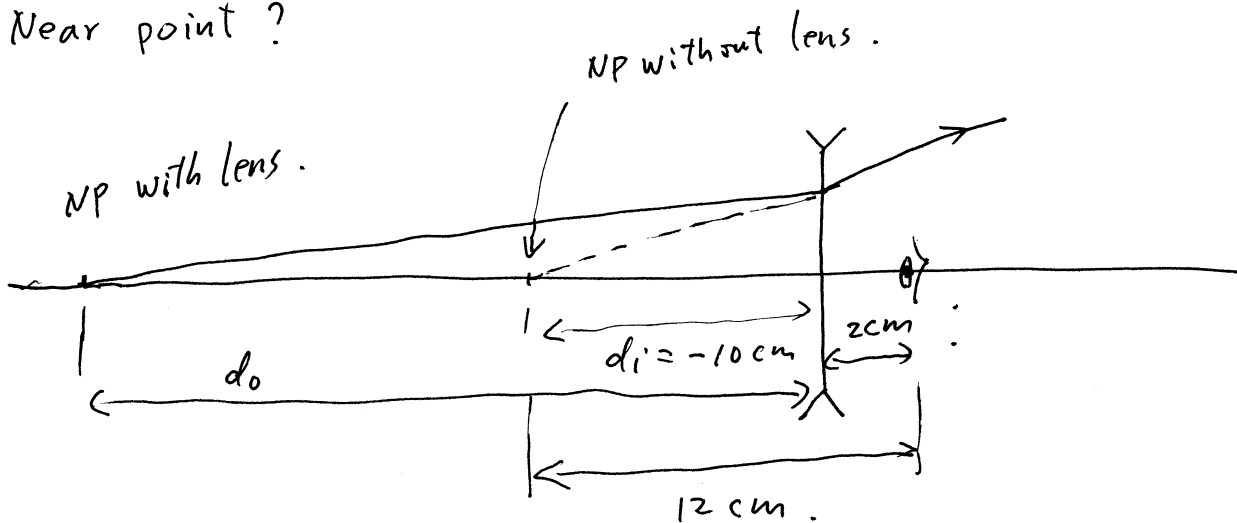
$$\text{Now: } d_i = -(17 - 2) = -15 \text{ cm} .$$

(sign of d_i : negative
 $\therefore$ Image is on object side.)

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

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

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.

$$\text{Find } f: \quad d_o = \infty, \quad d_i = -17 \text{ cm}.$$

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

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

$$\text{NP with contact: } f = -17 \text{ cm}, \quad d_i = -12 \text{ cm}$$

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

↳ too far!

e.g. 33-14.

$$f = 8 \text{ cm}.$$

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

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

b). at NP. $N = 25 \text{ cm}.$

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

(NOT required) .

25-9

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

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

b) . f_e , f_o .

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

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

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

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

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

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

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

$$= \frac{14.5 \times 0.29}{14.5 + 0.29} = \underline{\underline{2.52 \text{ cm}}}$$

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

c) $d_o \approx f_o$

$$= 0.29 \text{ cm} .$$