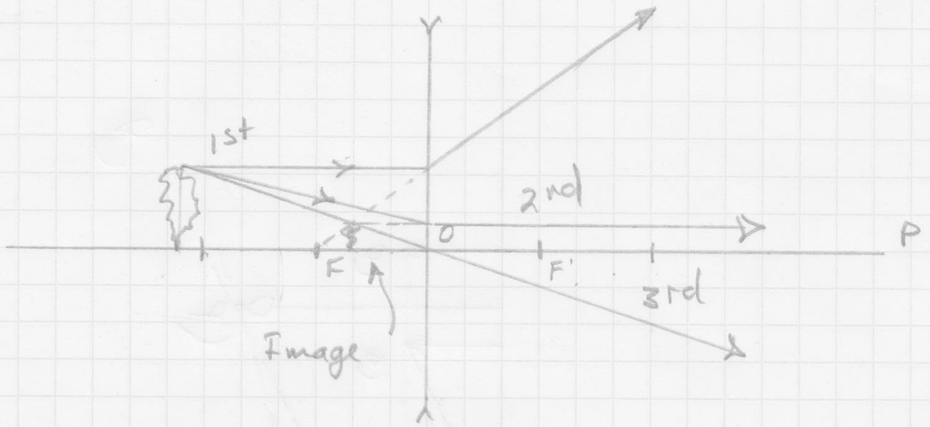
Section 4.4

Dr. Bob

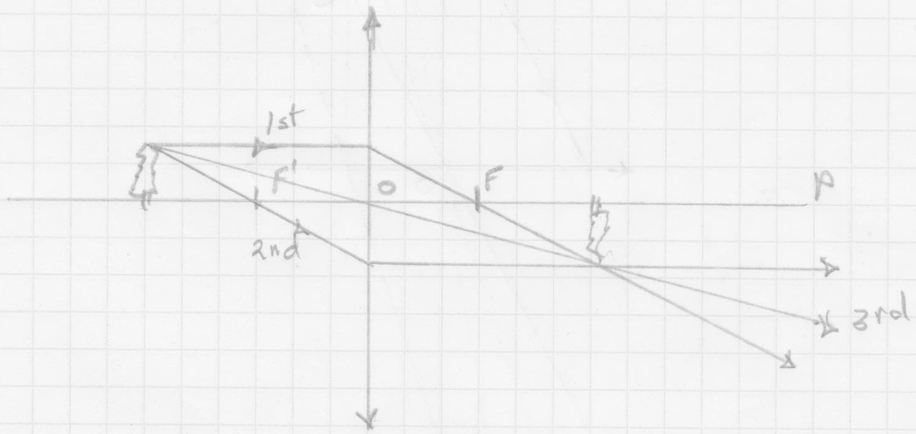
P. 122

1.



Upright Virtual

2.



Inverted Real

3.

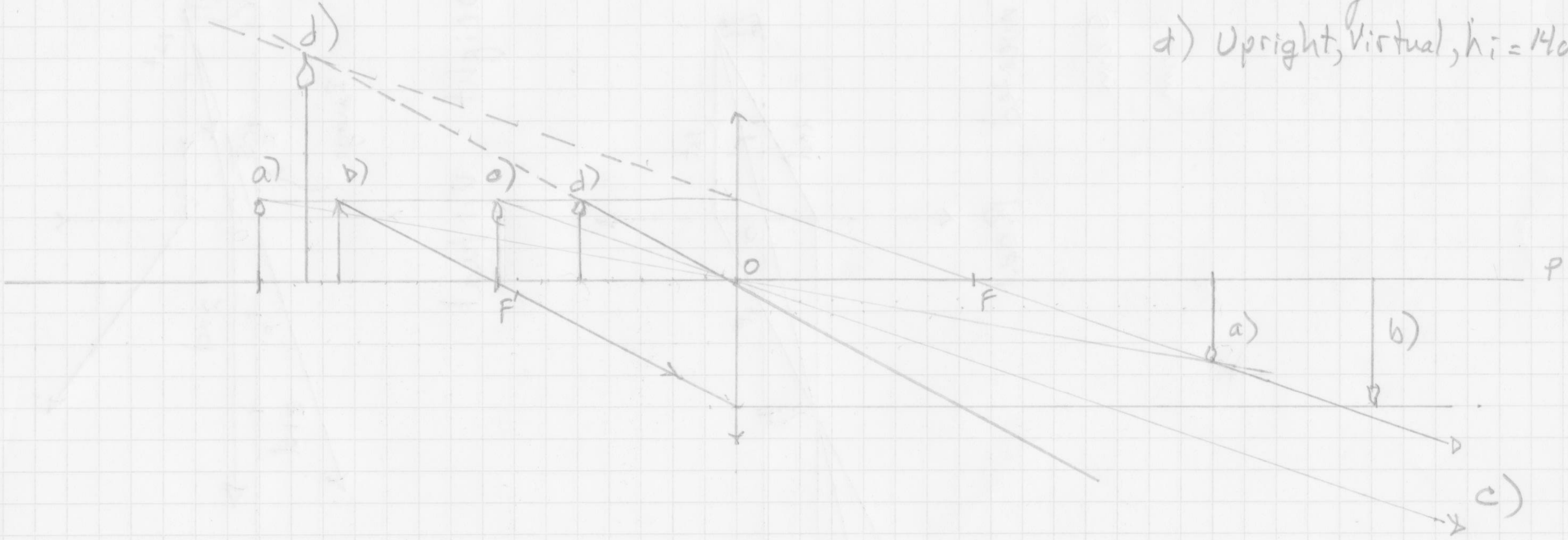
□ = 2cm x 2cm

a) Inverted, Real, $h_i = -5cm$

b) Inverted, Real, $h_i = -8cm$

c) No Image

d) Upright, Virtual, $h_i = 14cm$

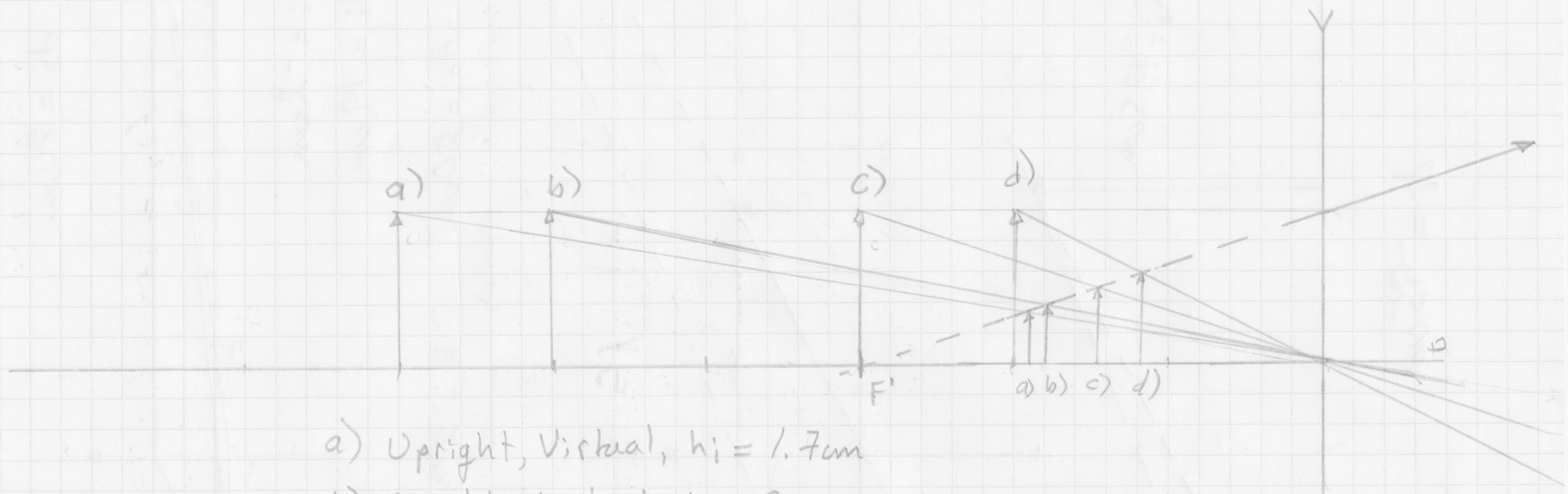


P.122 (continued)

4.

☐ 1cm x 1cm

Using 1st & 3rd principle rays



a) Upright, Virtual, $h_i = 1.7cm$

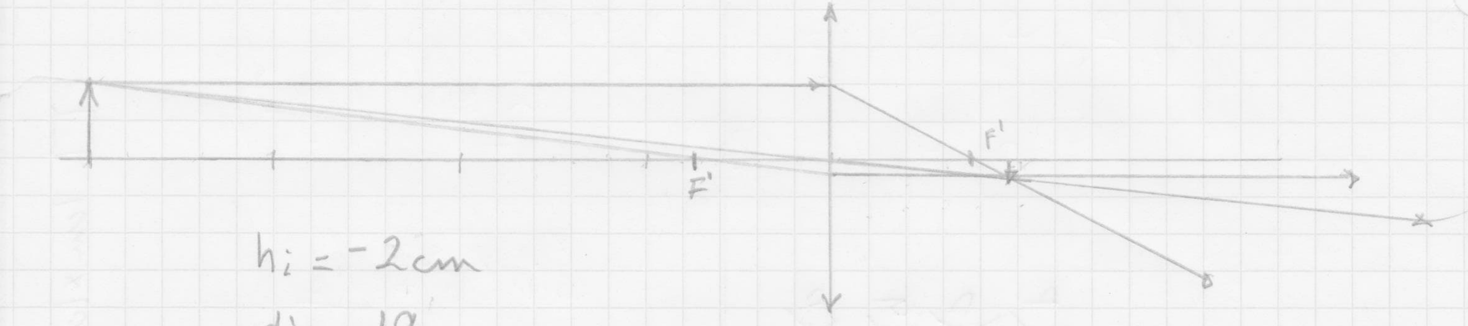
b) Upright, Virtual, $h_i = 2$ cm

c) Upright, Virtual, $h_i = 2.4cm$

d) Upright, Virtual, $h_i = 3.0cm$

5. $h_o = 8cm$ $f = 15cm$ □ $4cm \times 4cm$

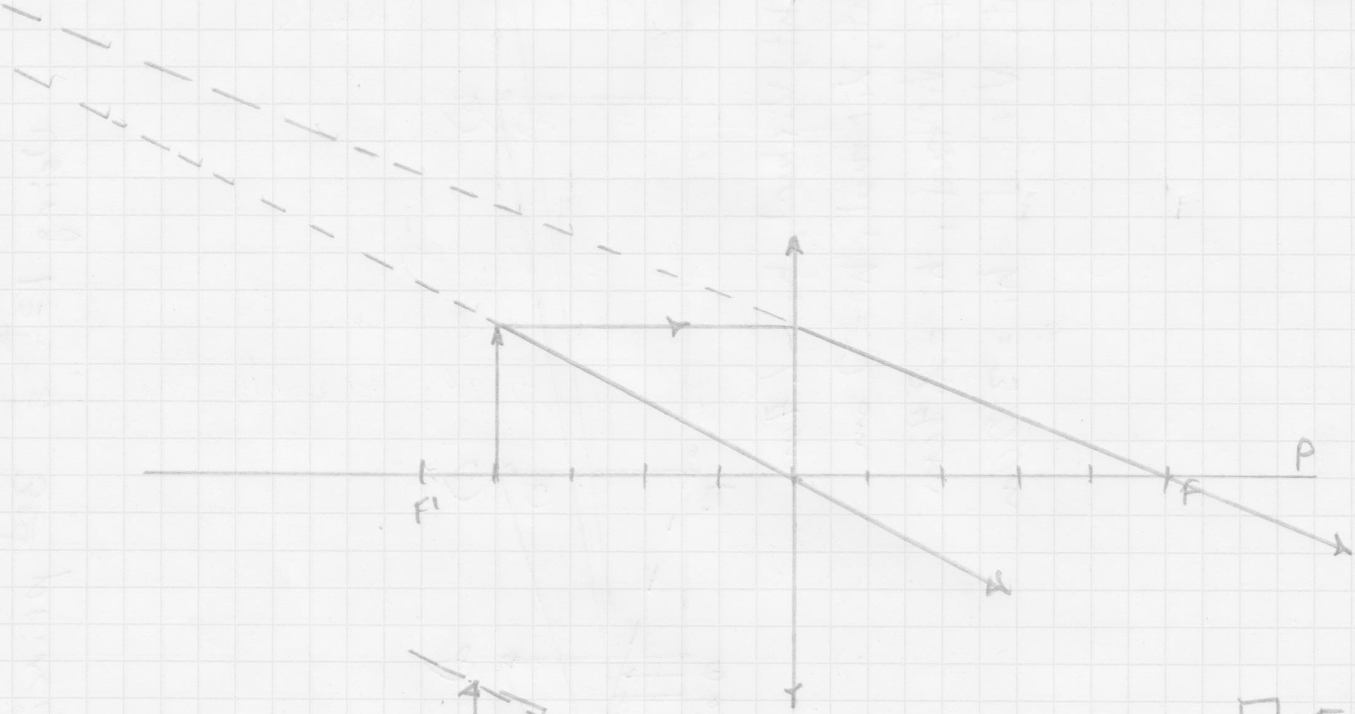
$d_o = 80cm$



$h_i = -2cm$

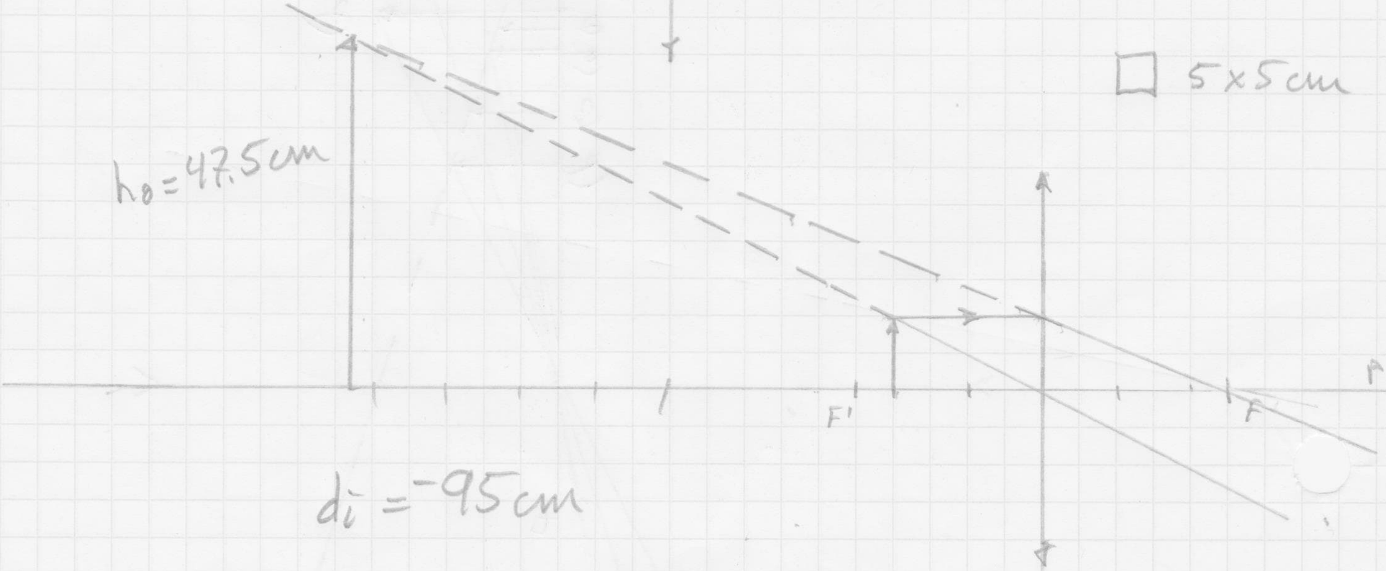
$d_i = 19cm$

6. $d_o = 20cm$ $h_i = 20cm$ $f = 25cm$ □ 2.5×25 cm



□ $5 \times 5 cm$

$h_o = 47.5cm$



$d_i = -95cm$

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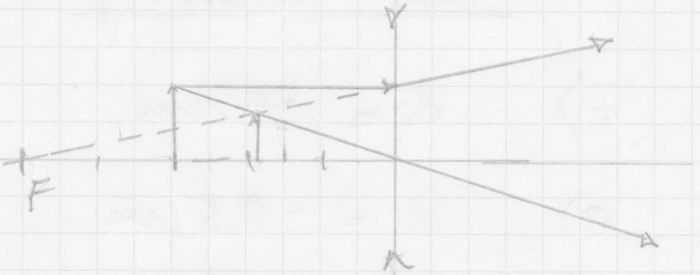
P. 122 (continued)

7. $h_o = 5cm$ $d_o = 15cm$ $f = -25cm$ ☐ 2.5 x 2.5 cm

$d_i = -8.5cm$

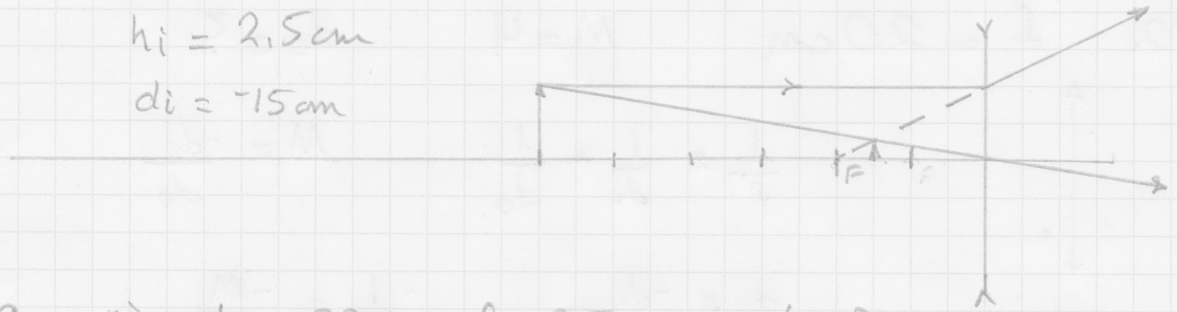
$h_i = 6 cm$



8. $h_o = 10cm$ $d_o = 60cm$ $f = -20cm$ ☐ 5 x 5 cm

$h_i = 2.5cm$

$d_i = -15cm$



9. 6) $d_o = 20cm$ $f = 25cm$ $d_i = ?$

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

$d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1} = \left(\frac{1}{25cm} - \frac{1}{20cm}\right)^{-1}$

$d_i = -100 cm$

7) $d_o = 15cm$ $f = -25cm$

$d_i = \left(\frac{1}{-25cm} - \frac{1}{15cm}\right)^{-1}$

$d_i = -9.4cm$

8) $d_o = 60cm$ $f = -20cm$

$d_i = \left(\frac{1}{-20cm} - \frac{1}{60cm}\right)^{-1}$

$d_i = -15 cm$

9. (continued)

Comparison

	Scaled drawing	Thin lens formula
7)	$d_i = -95\text{ cm}$	$d_i = -100\text{ cm}$
8)	$d_i = -8.5\text{ cm}$	$d_i = -9.4\text{ cm}$
9)	$d_i = -15\text{ cm}$	$d_i = -15\text{ cm}$

10. $f = 20\text{ cm}$ $M = 4$ $d_o = ?$

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

$$d_o = \frac{-d_i}{M} \qquad \frac{1}{d_o} = \frac{-M}{d_i}$$

$$\frac{1}{f} = \frac{1}{d_i} - \frac{M}{d_i} \qquad \frac{d_i}{f} = 1 - M$$

$$d_i = f(1-M)$$

$$d_i = 20\text{ cm}(1-4)$$

$$\boxed{d_i = -60\text{ cm}}$$

$$d_o = \frac{-d_i}{M} = -\frac{(-60\text{ cm})}{4} = 15\text{ cm}$$

$$d_o = 15\text{ cm}$$

Makes sense. $d_o < f \Rightarrow$ virtual image.

11.

Lens	Conv.	Diverg	Conv	Div	Conv
f (cm)	20	-20	10	-30	6.7
d_o (cm)	25	25	20	15	20
d_i (cm)	100	-11.1	20	-10	10
M	-4	0.44	-1	0.67	-0.5
Real/Virt	Real	Virt.	Real	Virt	Real
Orientation	Inv.	Upri.	Inv.	Upr	Inv

From problem 9 & 10 $f = \left(\frac{1}{d_i} + \frac{1}{d_o}\right)$ $d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)$

$$d_o = \left(\frac{1}{f} - \frac{1}{d_i}\right)$$

From problem 10. $d_o = \frac{-d_i}{M}$ $d_i = -d_o M$

$$M = \frac{-d_i}{d_o}$$

12. $M = 2$ $f = 10cm$

From problem 10 $d_i = f(1-M)$ $d_o = \frac{-d_i}{M}$

a) $d_i = 10cm(1-2) = -10cm$

$$\boxed{d_i = -10cm}$$

b) $d_o = \frac{-d_i}{M} = -\frac{(-10cm)}{2} = 5cm$

$$\boxed{d_o = 5cm}$$

c) Converging lens.

13. $M = 0.5$ $f = -20\,cm$

Again from problem 9 $d_i = f(1-M)$

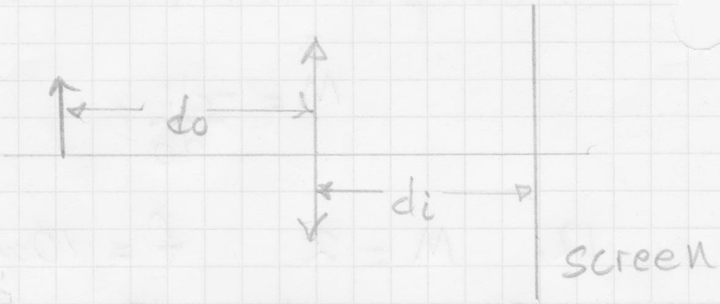
$M = \frac{-d_i}{d_o}$ $d_i = -d_o M$ $d_o = \frac{-d_i}{M}$

$$d_i = (-20\,cm)(1-0.5)$$
$$d_i = -10\,cm$$

$$d_o = -\frac{(-10\,cm)}{0.5} = 20\,cm$$

a) $d_i = -10\,cm$
b) $d_o = 20\,cm$
c) Diverging

14. $D = 36\,cm$
$f = 8\,cm$



$D = d_i + d_o = 36\,cm$
$d_i = D - d_o$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{D-d_o} + \frac{1}{d_o}$$ Multiply by $d_o(D-d_o)$

$$\frac{d_o(D-d_o)}{f} = d_o + D - d_o = D$$
$$d_o(D-d_o) = fD$$
$$-d_o^2 + d_o D = fD$$
$$d_o^2 - d_o D + fD = 0$$

14 (continued)

$$d_o^2 - D d_o + fD = 0$$

$$d_o^2 - (36\,cm)\,d_o + (8\,cm)(36\,cm) = 0$$

$$d_o^2 - (36\,cm)\,d_o + (288\,cm^2) = 0$$

This is a quadratic equation. The general form is $ax^2 + bx + c = 0$

The solutions are

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$d_o = x$ $a = 1$ $b = -36\,cm$ $c = 288\,cm^2$

$$d_o = \frac{36\,cm \pm ((-36\,cm)^2 - 4(1)(288\,cm^2))^{1/2}}{2(1)}$$

$d_o = 18\,cm \pm 16\,cm$ There are two roots. Which one is correct?

Case I $d_o = 24\,cm$

$$d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1}$$

$$= \left(\frac{1}{8\,cm} - \frac{1}{24\,cm}\right)^{-1}$$

$d_i = 12\,cm$

Case II $d_o = 12\,cm$

$$d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1}$$

$$= \left(\frac{1}{8\,cm} - \frac{1}{12\,cm}\right)^{-1}$$

$d_i = 24\,cm$

Both solutions work. They add to 36 cm. $d_i + d_o = 36\,cm$ was a condition to be met.

Place the lens either 12 cm or 24 cm in front of the candle.