NAME: SOLUTIONS DATE: 7/8

1. Determine the image distance and image height for a 5-cm tall object placed 45.0-cm from a double convex lens having a focal length of 15.0 cm.

CONVERGING

4

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \rightarrow \frac{1}{d_i} = \frac{1}{15cm} - \frac{1}{45cm}$$

$$\frac{1}{d_i} = 0.067 - 0.022$$

$$\frac{1}{d_i} = 0.045$$

$$d_i = \frac{1}{0.045} = 22.22cm$$

$d_i = 22.22cm$

2. Determine the image distance and image height for a 5-cm tall object placed 30.0-cm from a double convex lens having a focal length of 15.0 cm.

CONVERGING

4

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

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

$$\frac{1}{d_i} = \frac{1}{15cm} - \frac{1}{30cm}$$

$$\frac{1}{d_i} = 0.067cm^{-1} - 0.033cm^{-1}$$

$$\frac{1}{d_i} = 0.034cm^{-1}$$

$d_i = 29.41cm$

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = \frac{-29.41cm(5cm)}{30.0cm} = -4.90cm$$

$h_i = -4.90cm$ (inverted)

3. Determine the image distance and image height for a 5-cm tall object placed 20.0-cm from a double convex lens having a focal length of 15.0 cm.

converging

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

$$\frac{1}{20\text{cm}} + \frac{1}{d_i} = \frac{1}{15\text{cm}}$$

$$\frac{1}{d_i} = \frac{1}{15\text{cm}} - \frac{1}{20\text{cm}}$$

$$\frac{1}{d_i} = 0.016\,\text{cm}^{-1}$$

$d_i = 60\text{cm}$

$$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$h_i = -\frac{(5\text{cm})(60\text{cm})}{20\text{cm}} = -15\text{cm}$$

$h_i = -15\text{cm}$
inverted

4. Determine the image distance and image height for a 5-cm tall object placed 10.0-cm from a double convex lens having a focal length of 15.0 cm.

converging

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

$$\frac{1}{10\text{cm}} + \frac{1}{d_i} = \frac{1}{15\text{cm}}$$

$$\frac{1}{d_i} = \frac{1}{15\text{cm}} - \frac{1}{10\text{cm}}$$

$$\frac{1}{d_i} = 0.067\,\text{cm}^{-1} - 0.1\,\text{cm}^{-1}$$

$$\frac{1}{d_i} = -0.033\,\text{cm}^{-1}$$

$d_i = -30\text{cm}$

$$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$h_i = -\frac{(5\text{cm})(-30\text{cm})}{10\text{cm}}$$

$h_i = 15\text{cm}$
upright

M is -ive d_i = 32cm

5. A magnified, inverted image is located a distance of 32.0 cm from a double convex lens with a focal length of 12.0 cm. Determine the object distance and tell whether the image is real or virtual.

converging f +ive d_o

4

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

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

Since d_i is +ive
Image is real

$$\frac{1}{d_o} = \frac{1}{12cm} - \frac{1}{32cm}$$

$$\frac{1}{d_o} = 0.083cm^{-1} - 0.031cm^{-1}$$

$$\frac{1}{d_o} = 0.052\ cm^{-1}$$

d_o = 19.23 cm
REAL

d_o

6. **ZINGER**: An inverted image is magnified by 2 when the object is placed 22 cm in front of a double convex lens. Determine the image distance and the focal length of the lens.

converging d_i = ? f = ?

4/4 M = -2

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

$$-2 = -\frac{d_i}{22cm}$$

d_i = 44cm

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

$$\frac{1}{f} = \frac{1}{22cm} + \frac{1}{44cm}$$

$$\frac{1}{f} = 0.045cm^{-1} + 0.023cm^{-1}$$

$$\frac{1}{f} = 0.068\ cm^{-1}$$

f = 14.82 cm

7. A double concave lens has a focal length of -10.8 cm. An object is placed 32.7 cm from the lens's surface. Determine the image distance.

(diverging) f d_o $d_i = ?$

4

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

$$\frac{1}{d_i} = \frac{1}{(-10.8\text{cm})} - \frac{1}{(32.7\text{cm})}$$

$$\frac{1}{d_i} = -0.093\text{cm}^{-1} - 0.031\text{cm}^{-1}$$

$$\frac{1}{d_i} = -0.124\text{cm}^{-1}$$

$$d_i = -8.06\text{ cm}$$

$f = ?$ (diverging)

8. Determine the focal length of a double concave lens which produces an image which is 16.0 cm behind the lens when the object is 28.5 cm from the lens.

d_i d_o

4

$$\frac{1}{f} = \frac{1}{28.5\text{cm}} - \frac{1}{16\text{cm}}$$

$$\frac{1}{f} = 0.035\text{cm}^{-1} - 0.0625\text{cm}^{-1}$$

$$\frac{1}{f} = -0.0275\text{cm}$$

$$f = -36.36\text{cm}$$

9. A 2.8-cm diameter coin is placed a distance of 25.0 cm from a double concave lens which has a focal length of -12.0 cm. Determine the image distance and the diameter of the image.

h_o d_o (−diverging) f d_i h_i

4

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

$$\frac{1}{25\,cm} + \frac{1}{d_i} = \frac{1}{-12\,cm}$$

$$\frac{1}{d_i} = -0.083\,cm^{-1} - 0.04\,cm^{-1}$$

$$\frac{1}{d_i} = -0.123\,cm^{-1}$$

$d_i = -8.13\,cm$

$h_i = 0.909\,cm$

$f = -20\,cm$ (diverging)

10. The focal point is located 20.0 cm from a double concave lens. An object is placed 12 cm from the lens. Determine the image distance.

d_o d_i

4

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

$$\frac{1}{12\,cm} + \frac{1}{d_i} = \frac{1}{-20\,cm}$$

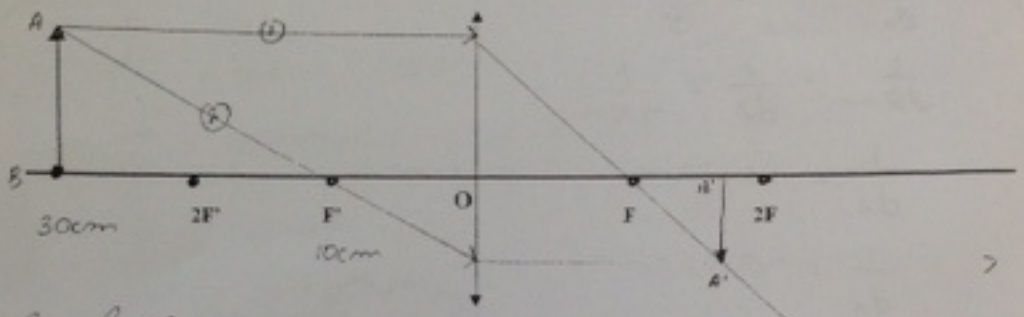
$$\frac{1}{d_i} = \frac{1}{-20\,cm} - \frac{1}{12\,cm}$$

$$\frac{1}{d_i} = -0.05\,cm^{-1} - 0.083\,cm^{-1}$$

$$\frac{1}{d_i} = -0.133\,cm^{-1}$$

$d_i = -7.52\,cm$

11. A thin converging (CONVEX) lens has a focal length of 10 cm (f). Find by (i) calculation and (ii) construction of a ray diagram, the position of the image of an object for the object distance d_o equal to 30 cm. Also find the magnification. Describe whether the image is real or imaginary, erect or inverted, magnified or diminished



By Ray Diagram

let h_o = 10cm (by scale)
(you can let it be any reasonable height)

- Image is Real
- Image is inverted
- Image is reduced

By Calculation

$f = 10cm$
$d_o = 30cm$

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

$$\frac{1}{10cm} = \frac{1}{30cm} + \frac{1}{d_i}$$

$$0.1cm^{-1} - 0.03cm^{-1} = \frac{1}{d_i}$$

$$0.07cm^{-1} = \frac{1}{d_i}$$

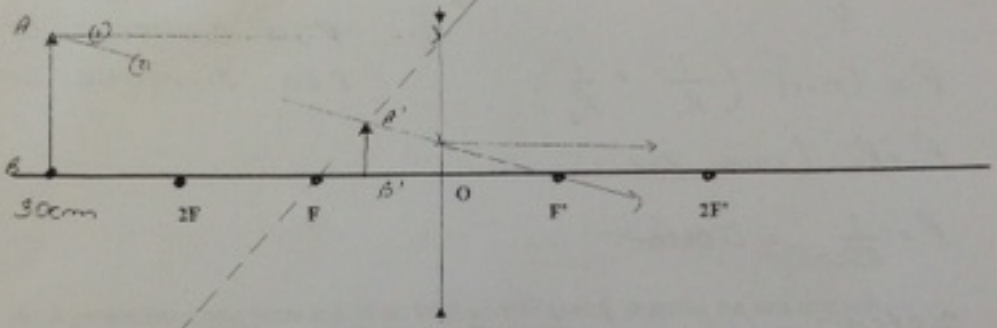
$d_i = 14.29cm$ (+ve d_i ∴ Real) ✓

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

$$M = -\frac{14.29cm}{30cm}$$

$M = -0.5$ (-ve ∴ inverted) ✓
(reduced)

12. A thin diverging lens has a focal length of 10 cm. Find by (i) calculation and (ii) construction of a ray diagram the position of the image of an object for object distance equal to 30 cm. Also find the magnification. Describe whether the image is real or imaginary, erect or inverted, magnified or diminished in size



By Ray Diagram
Image is virtual
Image is upright
Image is reduced

By Calculation

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

$$\frac{1}{-10\,cm} = \frac{1}{30\,cm} + \frac{1}{d_i}$$

$$-0.1\,cm^{-1} - 0.03\,cm^{-1} = \frac{1}{d_i}$$

$$-0.13\,cm^{-1} = \frac{1}{d_i}$$

$d_i = -7.69\,cm$ (-ive ∴ virtual) ✓

$$M = -\frac{d_i}{d_o} = -\frac{(-7.69)}{30} = 0.25$$ (+ive ∴ upright & reduced) ✓