Physics 111 Homework Solutions Week #8 - Wednesday

Friday, February 21, 2014

Questions

- None

Multiple-Choice

- None

Problems

- None

Monday, February 24, 2014

Questions

21.5 A plane mirror reverses left and right but not up and down. A converging lens when it produces a real image reverses up and down (if the object is upright, it's image is inverted.) This is one difference between the lens and the plane mirror. However, the converging lens also reverses left and right. To see this draw a ray diagram and see where the lines go. This is the same as the plane mirror.

21.12 See class notes for the explanation.

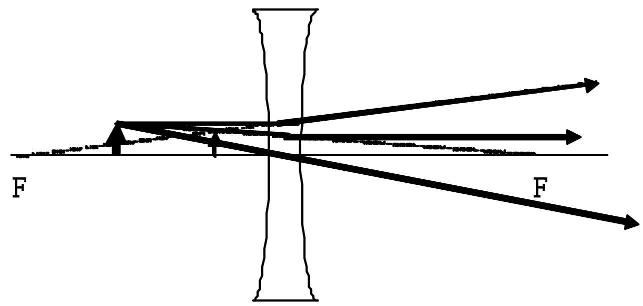
Multiple-Choice

21.1 B
21.2 A
21.3 D
21.4 A
21.5 B
21.6 C
21.7 A
21.17 C

Problems

21.1 Since the sun is essentially at infinity, the image distance is the focal length of the lens, which is 24 cm. Thus, the power $P = \frac{1}{f} = \frac{1}{0.24m} = 4.2D$.

21.2 Since the focal length of the lens is -0.2 m ($P = \frac{1}{f} \rightarrow f = \frac{1}{P} = \frac{1}{-5D} = -0.2m$), using the lens equation we have
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \rightarrow \frac{1}{-0.2m} = \frac{1}{0.12m} + \frac{1}{d_i} \rightarrow d_i = -0.075m = -7.5cm$. The image is virtual, located 7.5 cm behind the lens on the same side as the object. Compared to the insect's size as seen at the near point (taken to be 25 cm), the magnification is $M = \frac{25cm}{f} = \frac{25cm}{20cm} = 1.25$. A ray diagram follows:



21.5 To focus on objects very far away, use $d_o = \infty$ and then $d_i = f = d = 4\ cm$. So the camera is designed to focus at infinity with no extension of the lens. Then to focus on an object at do = 50 cm, we need $\frac{1}{50} + \frac{1}{4+x} = \frac{1}{4}$, where we have used $f = 4\ cm$ and the image is now located at $4 + x$. Solving for x, we find $x = 0.35\ cm$.

21.7 A creature swimming in a dish

a. The focal length is given by the thin lens equation
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{0.36m} + \frac{1}{4.5m} \rightarrow f = 0.33m$.

b. The velocity of the creature is magnified by the lens. Thus the magnification is $M = \frac{-d_i}{d_0} = \frac{-4.5}{0.36} = -12.5$. Thus the magnitude of the velocity on the screen is magnified by this same factor. In the dish the velocity is *1 cm/s* therefore the velocity on the screen is 1*2.5cm/s*.

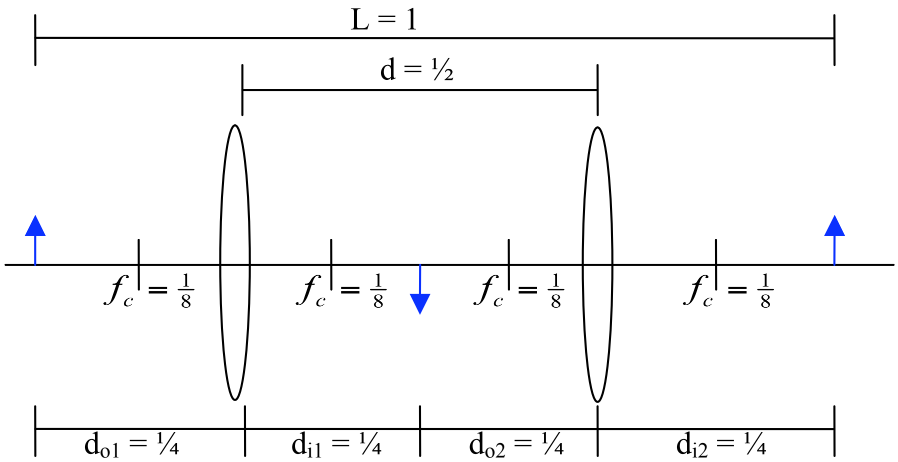
21.10 With $f = 20\ cm = 0.2\ m$, we can solve the lens equation for d_i to find that in general $d_i = \frac{1}{5 - \frac{1}{d_o}}$ so that we can fill in the following table with different values of d_o:

d_o (m)	d_i (m)
∞	0.20
4	0.21
2	0.22
1	0.25
0.8	0.27
0.6	0.30
0.4	0.40
0.2	∞

21.11 A lens relay system

a. The magnification is $M = 1$, so $d_o = d_i$ from magnification equation. Thus using the thin lens equation we find that the focal length is $\frac{1}{f} = \frac{2}{d_0} \to f = \frac{d_0}{2}$. To calculate d_o we use the fact that $d_o + d_i = L = 1m$ and thus $d_o = ½$ m. Therefore $f = ¼\ m$.

b. The relay system is shown below where all distances are in meters.



Here the magnification of the lens on the left is $M_L = -\frac{d_o}{d_i} = -\frac{1/4}{1/4} = -1$ while the magnification of the lens on the right is $M_R = -\frac{d_o}{d_i} = -\frac{1/4}{1/4} = -1$. Thus the total magnification is $M_T = M_L M_R = -1 \times -1 = 1$ as is required. The focal length of each lens is $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{1/4} + \frac{1}{1/4} \to f = \frac{1}{8} m$.

21.14 Tom Cruise being in addition to a skilled actor is also an accomplished physicist. To prove whether or not the reporter was trespassing he proceeds as follows. Since he knows about optics, Tom uses the thin lens and the magnification equations given by $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ and $M = \frac{d_i}{d_0} = \frac{h_i}{h_o}$ respectively. He needs to calculate d_o. Taking the magnification equation he solve it for d_i as $d_i = Md_o = \left(\frac{h_i}{h_o}\right)d_o$. Using this result and the thin lens equation he has

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o} + \frac{h_o}{h_i d_o} = \frac{1}{d_o}\left(1 + \frac{h_o}{h_i}\right).$$

$$d_o = \left(\frac{h_i + h_o}{h_i}\right)f = \left(\frac{2.89mm + 620mm}{2.89mm}\right) \times 210mm = 45 \times 10^3\, mm = 45m$$

Since this is about 135 feet, the reporter could be trespassing, as it depends on where Tom and the baby were standing on his property. More than likely the reporter was trespassing.