Name:_____KEY_____

Phys.116 Exam III
26 July 2004

Please do not turn the page until you are told to do so. When you do so, make sure that you have all three problems on your copy of the test.

In order to get credit on a problem, you must show your work. If you only write down an answer without the work leading up to it, you will get no credit for it, even if it is the right answer.

1. A 3.0-cm object is placed 8.0 cm in front of a mirror. The virtual image is 4.0 cm further from the mirror when the mirror is concave than when it is planar.

a.(10 points) Determine the focal length of the concave mirror.

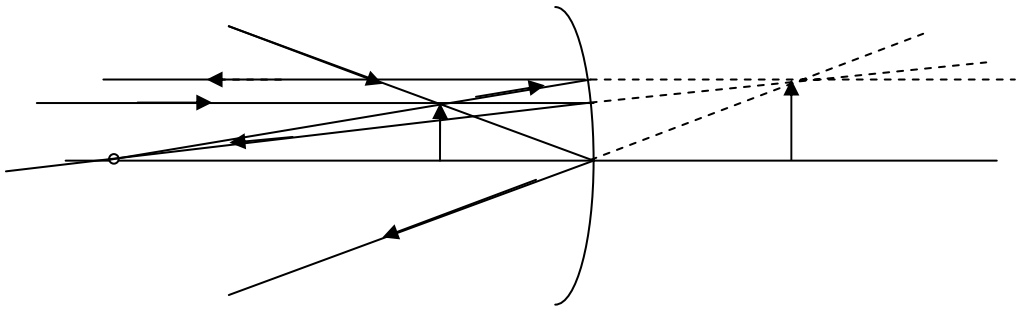
The image distance in the plane mirror would be 8.0 cm behind the mirror. Therefore, the image distance in the concave mirror will be 8.0+4.0=12 cm behind the concave mirror. Then,

$$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{8}-\frac{1}{12}=\frac{1}{24}\text{, so } f=24 \text{ cm}$$

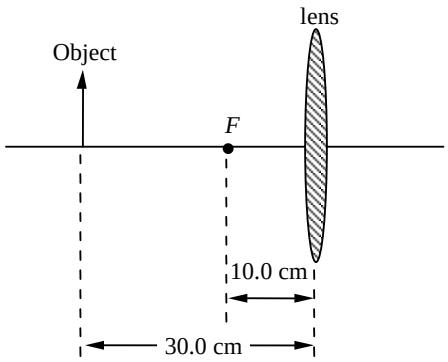
b.(5 points) Determine the image height in the concave mirror.

$$m=-\frac{d_i}{d_o}=\frac{h_i}{h_o};\ h_i=-\frac{d_i h_o}{d_o}=-\frac{-12(3)}{8}=4.5 \text{ cm}$$

c.(5 points) Please find the image by drawing the three main rays. Make sure that you draw the actual rays with solid lines, the extrapolated rays with dashed lines, and that you indicate the direction of the beams with arrows.



2. A 4.0-cm object is placed 30.0 cm from a converging lens that has a focal length of 10.0 cm as shown in the diagram.



a.(5 points) Where is the image located?

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

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{10.0} - \frac{1}{30.0} = \frac{2}{30.0}; \quad d_i = 15.0\ cm$$

b.(5 points) Determine the height and orientation of the image.

$$m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}; \quad h_i = -\frac{d_i h_o}{d_o} == -\frac{(15.0)(4.0)}{30.0} = -2\ cm$$

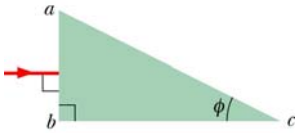
The negative sign indicates that the image is inverted.

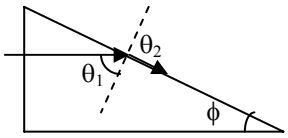
c.(10 points) A second converging lens is placed 20.0 cm to the right of the lens shown in the figure. Determine the focal length of the second lens if an inverted image (relative to the object in the diagram) is formed 13.3 cm to the right of the first lens.

The object distance is 20.0 – 15.0 = 5.0 cm. The image distance is 13.3 – 20.0 = -6.7 cm.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{5.0} + \frac{1}{-6.7} = \frac{1.7}{33.5}; \quad f = 19.7\ \text{cm}$$

3a. (10 points) A ray of light is perpendicular to the face *ab* of a glass prism (n=1.52). Find the largest value for the angle ϕ so that the ray is totally reflected at face *ac* if the prism is immersed in air.





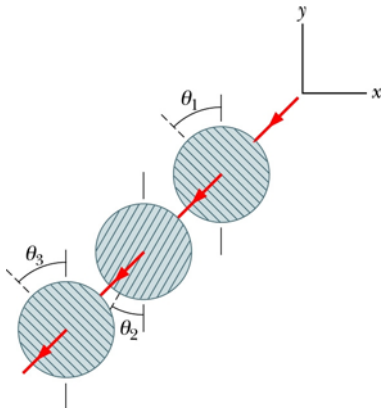
There is no refraction at the ab interface.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_1 = \sin^{-1}\frac{1\sin 90^o}{1.52} = 41^o$$

$$\phi = 90 - \theta = 49^o$$

3b. (10 points) Initially unpolarized light is sent through three polarizing sheets whose polarizing directions make angles of θ_1=40°, θ_2=20°, and θ_3=40° with the direction of the y-axis. What percentage of the light's initial intensity is transmitted by the system?



$$S_1 = \frac{S_0}{2}$$

$$S_2 = S_1 \cos^2(\theta_1 + \theta_2) = \frac{S_0}{2}\cos^2(\theta_1 + \theta_2)$$

$$S_3 = S_2 \cos^2(\theta_2 + \theta_3) = \frac{S_0}{2}\cos^2(\theta_1 + \theta_2)\cos^2(\theta_2 + \theta_3)$$

$$\frac{S_3}{S_0} = \frac{1}{2}\cos^2 60^o \cos^2 60^o = 0.03125 = 3.125\%$$