Homework Set #6 for General Physics 2, Nov. 14, 2016

1. [8 points] Figure 1 shows an overhead view of a corridor with a plane mirror M mounted at one end. A burglar B sneaks along the corridor directly toward the center of the mirror. If d = 3.0 m, how far from the mirror will he be when the security guard S can first see him in the mirror?

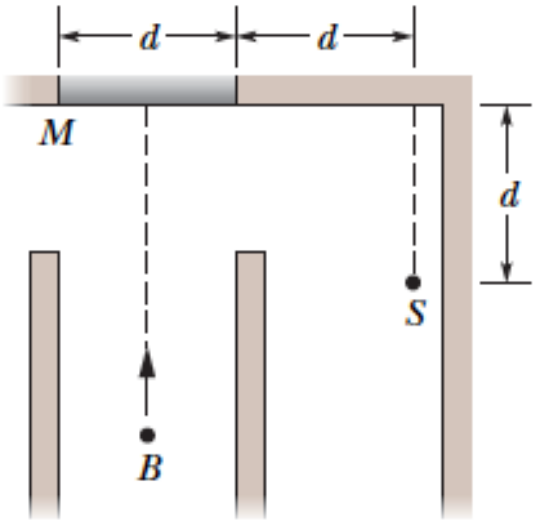

Figure 1

2. [8 points] A double-convex lens is to be made of glass with an index of refraction of 1.5. One surface is to have three times the radius of curvature of the other and the focal length is to be 90 mm. What is the (a) smaller and (b) larger radius?

3. [24 points] Object O stands on the central axis of a thin symmetric lens. For this situation, each problem in Table 1 gives object distance p (centimeters), the type of lens (C stands for converging and D for diverging), and then the distance (centimeters, without proper sign) between a focal point and the lens. Find (a) the image distance i and (b) the lateral magnification m of the object, including signs. Also, determine whether the image is (c) real (R) or virtual (V), (d) inverted (I) from object O or non-inverted (NI), and (e) on the same side of the lens as object O or on the opposite side.

Table 1

p	Lens	(a) i	(b) m	(c) R/V	(d) I/NI	(e) Side
+18	C, 4.0					
+10	C, 16					
+20	C, 35					
+12	D, 12					
+8.0	D, 6.0					
+20	D, 14					
+14	D, 31					
+40	C, 20					

4. [10 points] In Fig. 2, two light pulses are sent through layers of plastic with thicknesses of either L or 2L as shown and indexes of refraction $n_1 = 1.5$, $n_2 = 1.60$, $n_3 = 1.70$, $n_4 = 1.40$, $n_5 = 1.65$, $n_6 = 1.55$, and $n_7 = 1.45$. (a) Which pulse travels through the plastic in less time? (b) What multiple of L/c gives the difference in the traversal times of the pulses?

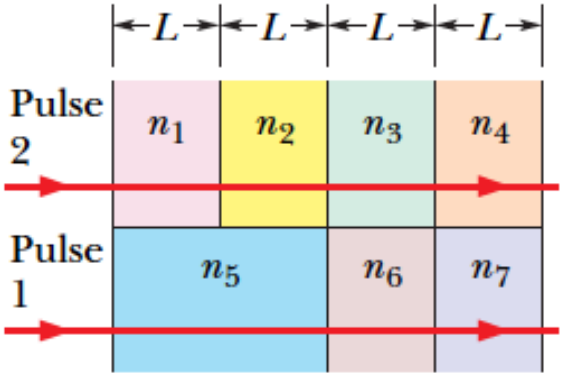

Figure 2

5. [10 points] Suppose that the two waves in Fig. 3 have wavelength $\lambda = 600$ nm in air. What multiple of λ gives their phase difference when they emerge if (a) $n_1 = 1.40$, $n_2 = 1.50$, and L = 9.0 mm; (b) $n_1 = 1.65$, $n_2 = 1.75$, and L = 9.00 mm; and (c) $n_1 = 1.47$, $n_2 = 1.67$, and L = 3.00 mm? (d) Suppose that in each of these three situations the waves arrive at a common point (with the same amplitude) after emerging. Rank the situations according to the brightness the waves produce at the common point.

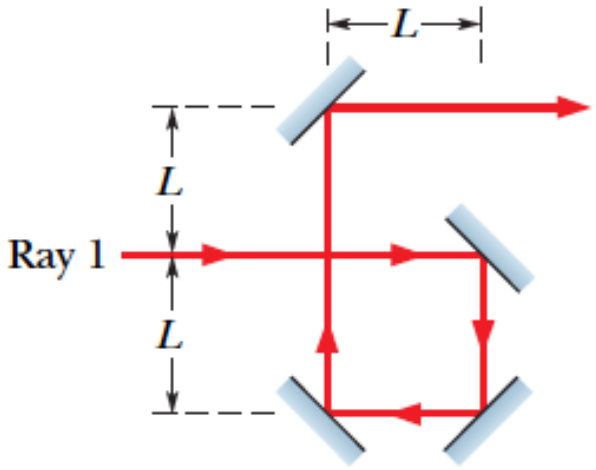

Figure 3

6. [10 points] In the double-slit experiment of Fig. 4, the viewing screen is at distance D = 5.00 m, point P lies at distance y = 22.0 cm from the center of the pattern, the slit separation d is 5.50 μm, and the wavelength λ is 600 nm. (a) Determine where point P is in the interference pattern by giving the maximum or minimum on which it lies, or the maximum and minimum between which it lies. (b) What is the ratio of the intensity I_P at point P to the intensity I_{cen} at the center of the pattern?

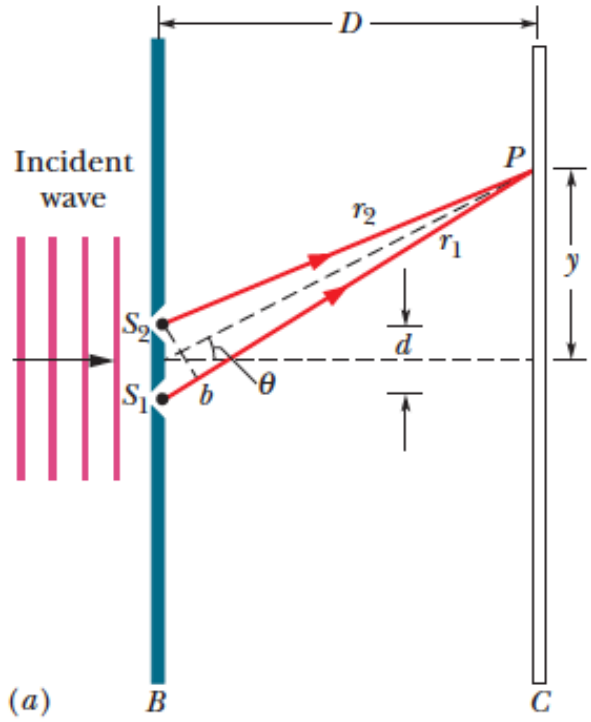

Figure 4

7. [10 points] The distance between the first and fourth minima of a single-slit diffraction pattern is 0.45 mm with the screen 50 cm away from the slit, when light of wavelength 450 nm is used. (a) Find the slit width. (b) Calculate the angle θ of the first diffraction minimum.

8. [10 points] (a) What is the angular separation of two stars if their images are barely resolved by the Thaw refracting telescope at the Allegheny Observatory in Pittsburgh? The lens diameter is 76 cm and its focal length is 14 m. Assume λ = 550 nm. (b) Find the distance between these barely resolved stars if each of them is 5 light-years distant from Earth. (c) For the image of a single star in this telescope, find the diameter of the first dark ring in the diffraction pattern, as measured on a photographic plate placed at the focal plane of the telescope lens. Assume that the structure of the image is associated entirely with diffraction at the lens aperture and not with lens "errors."

9. [10 points] In Fig. 5, first-order reflection from the reflection planes shown occurs when an x-ray beam of wavelength 0.240 nm makes an angle θ = 62.0° with the top face of the crystal. What is the unit cell size a_0?

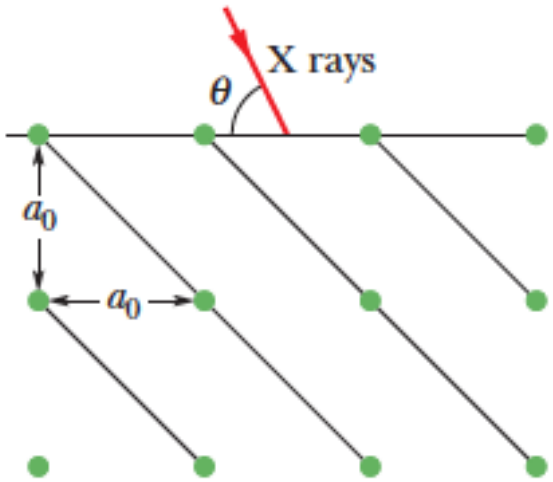

Figure 5