PHYSICS 1012 — Problem Set 5

Total – 35 marks — due March 22, 2022

As always, in the following you need to show how you got an answer – i.e., show your work. If you don't you will get 0 marks for the problem.

1. (4 marks) The mirrors in Figure 1 make a 60° angle as shown. A light ray enters parallel to the symmetry axis, as shown.

   (a) (2 marks) How many reflections does it make?

   (b) (2 marks) Where and in what direction does it exit the mirror system?

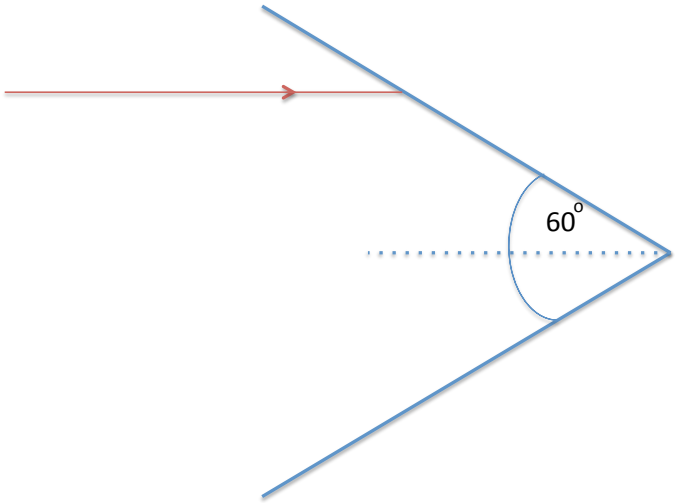

Figure 1: Figure for question 1.

2. (3 marks) Light propagating in the glass ($n = 1.52$) wall of an aquarium tank strikes the wall's interior surface with incidence angle 12.4°. What's the angle of refraction in the water?

3. (3 marks) What is the critical angle for light propagating in glass with $n = 1.52$ when the glass is immersed in water?

4. (4 marks) White light propagating in air is incident at 45° on the equilateral prism shown in Figure 2. Find the angular dispersion γ of the outgoing beam if the prism has refractive indices $n_{red} = 1.582$ and $n_{violet} = 1.633$.

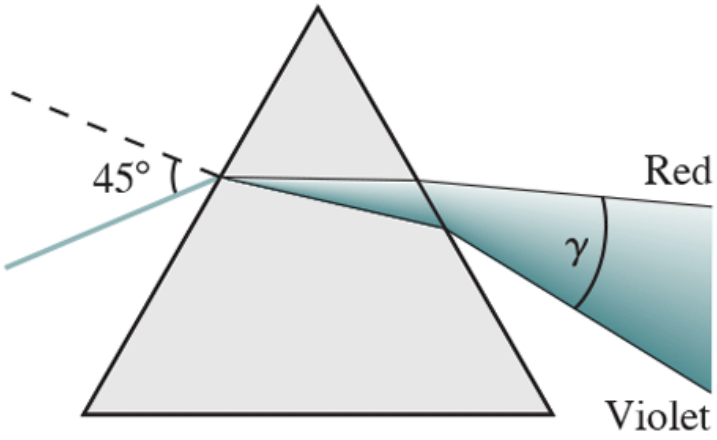

Figure 2: Figure for question 4.

5. (4 marks) You've dropped your car keys at night off the end of a dock into water 1.6 m deep. A flashlight held directly above the dock edge and 0.50 m above the water illuminates the keys when it's aimed at 40° to the vertical, as shown in Figure 3. What's the horizontal distance x from the edge of the dock to the keys?

6. (3 marks) A double-slit system is used to measure the wavelength of light. The system has slit spacing $d = 15$ μm and slit-to-screen distance $L = 2.2$ m. If the $m = 1$ maximum in the interference pattern occurs 7.1 cm from the screen centre, what's the wavelength?

7. (3 marks) A double-slit experiment with $d = 0.025$ mm and $L = 75$ cm uses 550 nm light. What's the spacing between adjacent bright fringes?

8. (2 marks) In a 5-slit system, how many minima lie between the zeroth-order and first-order maxima?

9. (3 marks) Light of wavelength 633 nm is incident on a 2.50 μm wide slit. Find the angular width of the central peak in the diffraction pattern, taken as the angular separation between the first minima.

10. (3 marks) What's the longest wavelength of light you could use to resolve a structure with angular diameter 0.44 mrad, using a microscope with a 1.2 mm diameter lens?

11. (3 marks) Find the minimum telescope aperture that could resolve an object with angular diameter 0.35 arcseond, observed at 520 nm wavelength. [Note: 1 arcsec = (1/3600)°]

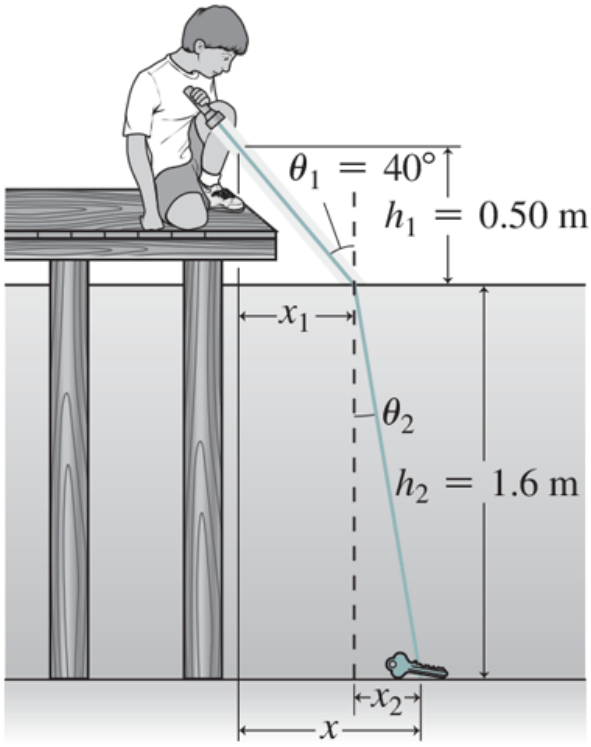

Figure 3: Figure for question 5.