

Physics 9, Fall 2018, Homework #6.
Due at start of class on Friday, October 26, 2018

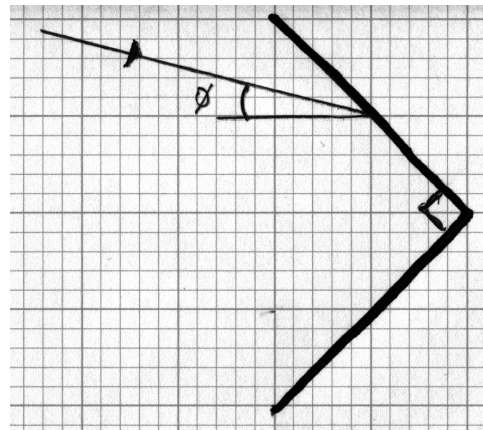
Problems marked with () must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.*

Optics problems

1. A planoconvex glass lens has one flat surface and one surface whose radius of curvature is 25.0 cm. (a) What is the focal length if $n = 1.50$ for glass? (b) What would the focal length be if instead both surfaces were convex with 25.0 cm radius of curvature? (c) How would your answer for part (b) change if the lens were immersed in water instead of air? You need the “lens-maker’s formula” to solve this problem (usually $n_0 = 1$ for air; flat surface $R = \infty$):

$$\frac{1}{f} = \left(\frac{n}{n_0} - 1 \right) \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

2. A corner reflector consists of two mirrors that meet at a 90° angle. (a) If incoming light strikes the first mirror at an angle ϕ w.r.t. the horizontal, as shown in the figure, at what angle w.r.t. the horizontal will it leave the second mirror? (b) Can you think of a reason why this sort of mirror combination (perhaps a large number of small corner reflectors) might be embedded into stop signs’ white lettering, into bicycle reflectors, etc.? (c) How would you design a corner reflector that would work not just for vertical angles, but also for horizontal or diagonal angles (i.e. in 3D)?



3. Photographs taken by spy planes can reportedly resolve features as small as 5 cm. These planes fly at very high altitudes (20 km) to avoid being shot down. At least how wide must a spy plane’s camera lens be in order to see these small details? Evaluate your answer (a) for red light (630 nm), and (b) for blue light (450 nm). (Find the “angle subtended” by the distant object, then use the “Rayleigh criterion” $\theta = 1.22\lambda/D$ for the angular resolution (in radians) of a lens of diameter D .)

4. The sun and moon appear in the sky to be about the same size. (You can see this most impressively during a total eclipse of the sun.) The moon is a distance 3.8×10^8 m from earth, and the sun is a distance 1.5×10^{11} m from earth. The radius of the moon is 1.7×10^6 m. (a) Given the above information, how large is the sun? (b) Why do they appear—to the eye—to be the same size? (Hint: “angle subtended.”)

5. I shine my laser pointer onto two very narrow slits that are spaced $50 \mu\text{m}$ (5.0×10^{-5} m) apart. A pattern of bright spots appears on a screen that is 50 feet away. Near the center of the pattern, the bright spots are 16.2 cm apart. (a) What is the wavelength of the light? (Be sure to check that

the answer that you get is reasonable for a laser pointer.) (b) What is the oscillation period (in seconds) of light at this wavelength?

6. You can tell whether a person is farsighted or nearsighted by looking at the width of the face through his or her glasses. If the person's face appears wider through the glasses, is the person farsighted or nearsighted? Draw a diagram to support your answer. (You can take it as a given that eyeglasses for far-sightedness use converging lenses, while eyeglasses for near-sightedness use diverging lenses. If you choose to "prove" this instead of assuming it, you can earn two extra points.)

Fluids problems

7. A 10.0 cm cube floats in water with 7.00 cm submerged. (The top surface of the cube conveniently stays horizontal.) What is the mass of the cube?

8. Lumber (let's say eastern white pine) used in building construction has a specific gravity of around 0.4 and can withstand a pressure of about 3×10^6 Pa before crushing (when loaded perpendicular to the grain, as when stacking up a pile of lumber). How tall a pile of lumber could you make before the bottom of the pile crushed under the weight (per unit area) of the pile?

9. A spherical balloon is filled with helium to lift a 1.50 kg payload off the ground. The empty balloon weighs 0.50 kg. What is the minimum diameter of the balloon? (The density of air is 1.286 kg/m^3 , and the density of helium is 0.179 kg/m^3 .)

10. You have a cubic box, 0.40 m on a side. If you are strong enough to lift 50 kg on earth, what is the largest mass for this box that you can lift when it is completely submerged in water, with the top of the box 10 m below the surface? Would your answer be different if the top of the box were 20 m below the surface?

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XC1*. Optional/extra-credit. A lens of 80 mm focal length is used to focus an image onto the film of a camera. The largest possible distance between the lens and the film is 120 mm. (a) How far in front of the film should the lens be if the object to be photographed is 10.0 m away? (b) 3.0 m away? (c) 1.0 m away? (d) What is the closest object this lens could photograph with a clear image?

XC2*. Optional/extra-credit. Suppose you are building a Kepler-style telescope (in which both lenses are converging lenses) to look up at the moon. The objective lens has a focal length of 85 cm, and the eyepiece has a focal length of 3.0 cm. (a) What is the magnification? (b) Will the image be upright or inverted? (c) What is the overall length of the telescope, assuming that the viewer's eye is relaxed (i.e. focused very far away). (d) Draw a ray diagram showing at least two rays from the moon traveling through both lenses and into your eye. (Your drawing doesn't need to be to scale.)

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