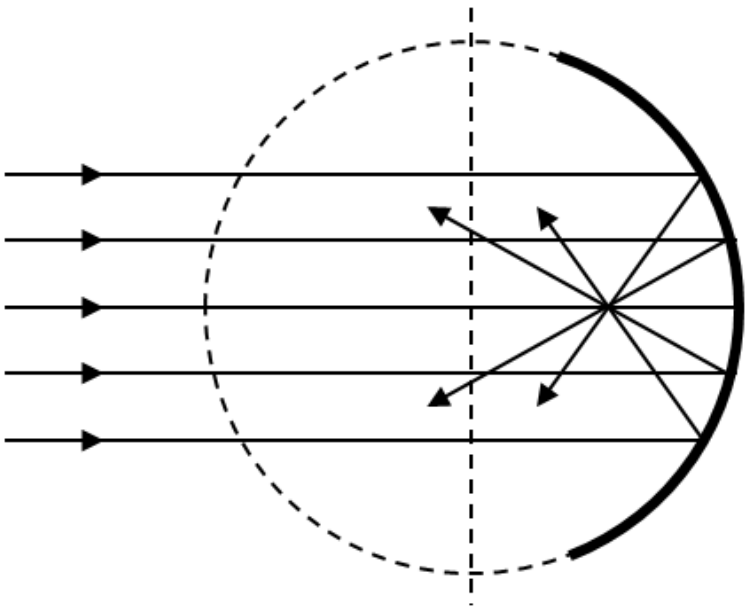
4.9 PROBLEMS

Problem 4.9.1. Draw the wave fronts for incident and reflected rays from a concave mirror as they pass through a focus and beyond in the following figure. (Hint: To obtain the wavefronts near the focus, imagine putting a light source there.)



Problem 4.9.2. Draw wave fronts for parallel incident rays and the rays after emerging from a diverging lens.

Problem 4.9.3. A plane electromagnetic wave in glass is given by the following traveling wave.

$$\vec{E} = \hat{u}_y \ \left(3 \times 10^{-6} \text{ N/C}\right) \ \cos\left[10^{15} \ \pi \left(t - 1.6\frac{x}{c}\right)\right]$$

Find the following.

(a) the frequency of the light,

(b) the wavelength,

(c) the speed of the light in the glass,

(d) the refractive index of glass, and

(e) the intensity.

Problem 4.9.4. An astronaut is at a distance of $R/4$ from the Sun, where R is the average Earth-Sun distance. He holds a perfectly reflecting mirror of area A perpendicular to the rays from the Sun. Find his acceleration due to the radiation pressure alone if his mass

along with all the gear is M. Assume that the astronaut is completely behind the mirror so that light strikes the mirror only and the intensity of the sunlight at Earth is I_E. Ans: $a = \dfrac{32 I_E A}{Mc}$.

Problem 4.9.5. A perfectly absorbing cylindrical pellet of cross-sectional area A and mass m is to be suspended near Earth's surface. Assume the orientation of the pellet lengthwise vertical and light strikes only one end and not the sides. Find the intensity of light needed. Ans: $\dfrac{Mgc}{A}$.

Problem 4.9.6. No light passes through two crossed Polaroids whose axes are 90° to each other. Light however can pass if a third Polaroid is inserted between the two. What should be the angle the Polaroid in the middle should make with the first Polaroid so that the intensity of the transmitted light is 5% of the intensity of unpolarized light incident on the first Polaroid. Ans: 19.7°.

Problem 4.9.7. A Polaroid is rotated between two fixed crossed Polaroids at a frequency of f Hz. Find the variation of emergent intensity with respect to time in terms of the incident intensity I_0 of the unpolarized light and the frequency f of rotation of the rotating polaroid. Ans: $\frac{1}{8}\sin(4\pi f t)$.

Problem 4.9.8. An unpolarized light of intensity 50 W/m^2 is incident normally on the first of a three linear polarizers placed in a line and oriented as follows. The axis of the second polarizer makes an angle of 30° with the axis of the first polarizer and the axis of the third makes an angle of 60° with the axis of the second polarizer. (a) Determine the intensity of the transmitted light behind the first polarizer. (b) Determine the intensity of the transmitted light behind the second polarizer. (c) Determine the intensity of the transmitted light behind the third polarizer. (d) Determine the intensity of the transmitted light if the second polarizer is removed. Ans: (a) 25 W/m^2, (b) 19 W/m^2, (c) 4.7 W/m^2, (d) 0.

Problem 4.9.9. The reflected light from the surface of water (refractive index 4/3) is polarized if the angle of reflection is equal to the Brewster's angle θ_B. If you are wearing a polaroid glasses whose axis is 10° from vertical, what is the intensity of light at your eyes if the intensity of the light before reflection from the water surface was 100 W/m^2? Ans: 1.5 W/m^2.