Portland State University
General Physics Workshop
Problem Set 4 **Polarization and Mirrors**

Equations and Relations:

Transmission of polarized light:
$I = I_0 \cos^2 \theta$

Transmission of unpolarized light:
$I = \frac{1}{2} I_0$

Total polarization
$\tan \theta_B = \frac{n_2}{n_1}$
θ_B Brewster's angle

Focal length, *f*, of a convex mirror:
$f = -\frac{1}{2} R$

Concave:
$f = \frac{1}{2} R$
R: radius of curvature

Mirror Equation:
$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$
d_o: object distance
d_i; image distance

Magnification:
$m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$

1.
A vertically polarized beam of light of intensity 100 W/ m^2 passes through two polarizers. The transmission axis of the first polarizer is making an angle of 20° to the vertical and the second one is making an angle of 110° to the vertical.

(a) What is the transmitted intensity of this beam of light?

A third polarizer is added before the first polarizing sheet. The transmission axis of the polarizer is making and angle of 60° to the vertical.

(b) What is the transmitted intensity after the first two polarizers?

(c) What is the total transmitted intensity after all three polarizers?

Now the polarizer at 60° is moved in between the other two polarizers.

(d) What is the total transmitted intensity after all three polarizers in this case?

(e) What is the total transmitted intensity after all three polarizers if the initial light beam was unpolarized?

2. Two rays, emitted from the same point, diverge with an angle of 15° between them. The rays reflect from a plane mirror. Draw a ray diagram and find the angle between the two rays after the reflection.

3. Construct the images formed by a concave mirror when the object is
   (a) beyond the center of curvature, *C*,
   (b) at *C*,
   (c) between *C* and the focal point *F*,
   (d) at *F*, and
   (e) between *F* and the mirror's surface.
   Discuss the nature and relative size of each image.

4. An object 2 cm in height is placed at the center of curvature C in front of a concave mirror. What is the height of its image?

5. An object 1.5 cm in height is placed 7 cm in front of a concave mirror with a radius of curvature of 5 cm.
   (I) Draw a ray diagram to scale and measure
      (a) the location
      (b) the height
      (c) the magnification
   of the image.

   (II) Analytically calculate location, height, magnification and compare the values to the graphical result.
   (III) Calculate location, height, and magnification if the object is placed 7 cm in front of a convex mirror with a radius of curvature of -5 cm.

6. A dentist places a mirror 1.5 cm from your tooth. He sees an enlarged image 4 cm behind the mirror.
   (a) What is the focal length of the mirror?
   (b) What is the magnification ?
   (c) Is the dentist's mirror concave or convex?
   (d) Is the image upright?

- *When you look at the back side of a shiny teaspoon at arm's length you see yourself upright. When rotate the spoon and you look at front side you are upside down. Explain the nature of both images.*

- *Use the mirror equation to show that the image of an infinitely distant object is formed at the focal point of a spherical mirror.*

- *Use the mirror equation to show that the image of an object placed at the focal point of a concave mirror is located at infinity.*

- *Use the mirror equation to show that, for a plane mirror, the image distance is equal in magnitude to the object distance. What is the magnification of a plane mirror?*

Additional Questions

1. Discuss the statement: One cannot "see" the surface of a perfect mirror.

2. Why is the passenger's side mirror in many cars convex rather than plane or concave?

3. When a virtual image is formed by a mirror, is it in front of the mirror or behind it? What about a real image?

4. If you look at mirror and see the image of clock, do the hands rotate clockwise or counterclockwise.

5. Why is the receiving antenna of a satellite dish placed at a set distance from the dish?