

**PHYSICS 8B – Fall 2009**  
**Mid-term 2**  
**C. Bordel**  
**Monday, November 9, 2009**  
**6:30pm-8:30pm**

**Problem 1 (10 pts.)**

A radar emits planar monochromatic waves of wavelength  $\lambda = 60$  cm at the speed of light ( $c = 3 \times 10^8$  m/s). For this wave, find the following (be sure to include the appropriate units in your answer!)

- a) The magnitude of the wave vector,  $k$ .
- b) The frequency,  $f$ .
- c) The angular frequency,  $\omega$ .
- d) The period,  $T$ .

**Problem 2 (20 pts.)**

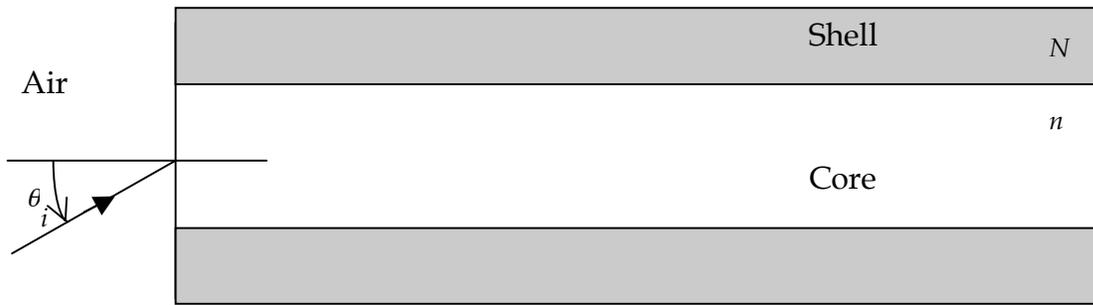
A 1.80 m tall woman is designing a plane mirror for herself. The woman wants to be able to see her entire image in the mirror and wants to make the mirror as small as possible. Her eyes are 10 cm below the top of her head.

- a) What height should the woman make the mirror and how high off the bottom of the floor should she mount it? Show that she can see her entire image by making a drawing.
- b) If the woman has imperfect eyesight and sees only blurred images for objects farther than 4 m away, what is the maximum distance between the woman and the mirror so that she can see her image entirely clear? Again, make a drawing in support of your answer.

**Problem 3 (20 pts.)**

A light ray hits the entering surface of an optical fiber with an angle of incidence  $\theta_i$ , as shown in the figure below. The fiber is made of a *core* with index of refraction  $n$  surrounded by a *shell* with index of refraction  $N$ . The light ray enters from an air-filled region ( $n_{\text{air}} = 1$ ).

- a) What is the relationship between the light ray's angle of incidence  $\theta_i$  and the light ray's angle of refraction  $\theta_r$  with respect to the normal after entering the core? Make a qualitative drawing showing the refraction at the air-core interface.

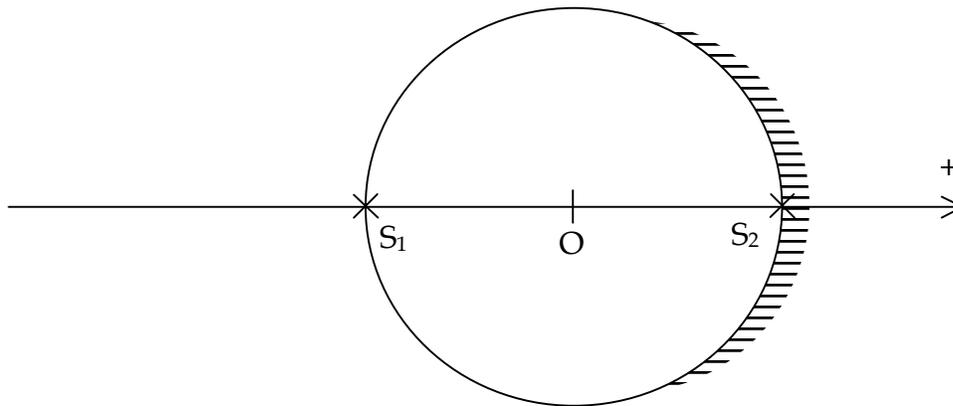


- b) What is the critical angle of incidence,  $\varphi_c$ , of a light ray in the core with respect to the core-shell interface that leads to total internal reflection at the core-shell interface? Calculate  $\varphi_c$  for the values  $N = 1.4$ ,  $n = 1.5$ .
- c) What is the condition for the initial angle of incidence,  $\theta_i$  from part (a), so that total internal reflection occurs within the fiber core, as in part (b)? Qualitatively draw the behavior of a light ray with an angle of incidence  $\theta_i = 20^\circ$ .

**Problem 4 (25 pts.)**

Consider a sphere whose center is at  $O$  with a radius  $R$  made of a material with refractive index  $n$ . The sphere has a silver coating on its right hemisphere, so that the right surface acts as a spherical reflector, as shown in the figure below.

A point object,  $A$ , is positioned to the left of the sphere in air ( $n_{\text{air}} = 1$ ).



- a) As a light ray propagates from the object  $A$  to the final image  $A'$ , at what surfaces will it experience reflection and/or refraction?
- b) For each of the reflections and refractions above, write down the appropriate relation that will allow us to trace the light ray. You may assume that the sphere is much bigger than the height of the object so that we can use the *small-angle approximation*.

- c) Determine the relationship between the object's position,  $d_o$ , and the image's position,  $d_i$ .
- d) Numerical Calculation: If  $A$  is located 20 cm to the left of the optical system, and the sphere's radius is 10 cm and made from glass (index of refraction  $n_{\text{glass}} = 1.5$ ), where does the image  $A'$  form?

**Problem 5 (25 pts.)**

For this problem, consider the human eye as a biconvex lens of variable focal length  $f$ , located in front of a physiological "screen", called *retina* (where the image forms). The distance between the lens and the retina is 1.5 cm.

- a) We first consider a normal eye.
  - i) What range of object distances can a normal eye accommodate?
  - ii) Make a ray-tracing drawing showing the image formation of a very distant object.
  - iii) In what range of values does the focal length  $f$  vary?
- b) We now consider a defective eye that can only see objects located between 10 cm and 80 cm in front of it.
  - i) Describe this defect and say what it is called.
  - ii) What type of corrective lens should be used to correct the eyesight so that distant objects can be seen? Give the focal length and focusing power, assuming that the distance between the corrective lens and the eye is negligible.
  - iii) What is the near point of the corrected eye?