Physics 7C, Fall 2000

Midterm II

Tuesday, November 3, 6:30-8:30 p.m.

Print Name:

Signature:

Student ID:

Discussion Section #:

Discussion Section GSI:

For grading use:

Problem 1 (25 points):

Problem 2 (25 points):

Problem 3 (25 points):

Problem 4 (25 points):

Directions: The allotted time is 110 minutes. No notes or calculators are allowed. The 4 problems count equally, and some parts are easier than others, so you will want to take a look at all of them.

a) Box or circle all of your final answers.

b) Explain briefly how you reached your answer. A clear explanation of what you are doing also helps in getting partial credit if there is a mistake somewhere. When a numerical answer is called for, an accuracy of 5% is sufficient.

Please do not turn this sheet over until the proctor starts the exam. You may ask the proctor for help if a question's meaning is unclear.

1. Consider rays of light at the interface between glass (index of refraction 1.5) and air (index of refraction 1).

(a) (10 points) Draw pictures of what happens to rays incident from the air side at two angles of incidence: $\theta = 0$ (normal incidence) and $\theta = 45°$. Show clearly which side is air, which side is glass, and both reflected and transmitted directions. Make clear how the ray bends on crossing the interface, if it does.

(b) (5 points) Is total internal reflection (TIR) possible for light incident from the *air* side? If so, write an expression for which incident angles will lead to TIR. You do not need to evaluate trigonometric functions.

(c) (5 points) Is total internal reflection (TIR) possible for light incident from the *glass* side? If so, write an expression for which incident angles will lead to TIR. You do not need to evaluate trigonometric functions.

(d) (5 points) Does light travel faster on the air side or on the glass side? In terms of the speed of light in vacuum c, what are the speeds on the two sides?

2. Consider a double-slit interference experiment using a source of wavelength $\lambda = 1$ cm. The target screen is 100 meters away from the two slits.

(a) (10 points) Assume as usual that the source generates a plane wave that reaches the two slits at the same time. How far apart should the two slits be if the spacing between intensity maxima on the target screen is to be 1 m? For parts (a) and (b), but not (c), you may ignore diffraction effects.

(b) (5 points) Now assume that the source is moved slightly, so that its plane waves are at an angle of incidence ϕ to the screen with the slits (before $\phi = 0$). Draw a picture and explain how the observed intensity pattern is changed.

(c) (10 points) Now go back to $\phi = 0$ and include diffraction. Assume that the slits have equal width D. On carrying out this experiment, you notice that there are 5 equally spaced bright peaks on the target screen in the central region. (That is, there are no peaks observed at the points where the next two peaks, one on each side, would be from interference alone.) From this observation, what can you conclude about the ratio between the center-to-center slit separation d and the width of each slit D?

3. (a) (5 points) We want to design a concave spherical mirror for a telescope so that an object very far away will form an image 1 m from the mirror. What is then the focal length of the mirror? What should its radius of curvature be?

(b) (15 points) Now an object is placed 5 m away from the mirror in (a), along its axis. Draw a ray diagram to illustrate where the image forms. Is this a real or virtual image? How far is the image from the mirror?

(c) (5 points) Consider a convex mirror with a focal length of -1 m. For the object 5 m away as before, where does the image form? Is this a real or virtual image?

4. (a) (10 points) Linearly polarized light with $\mathbf{k}||\hat{\mathbf{z}}$ and $\mathbf{E}||\hat{\mathbf{x}}$ is normally incident upon a ideal polarizing film of unknown polarization axis. Sketch how the intensity of the light on the other side of the polarizing film varies as the polarizing film is rotated through 2π. Indicate how the maximum and minimum transmitted intensity are related to the original intensity.

(b) (8 points) Consider light of wavelength λ traveling in air. The light is incident at normal incidence upon a thin film of oil with index of refraction $n_o > 1$. On the other side of the thin film is water with index of refraction $n_w > n_o$. Write the values of the film thickness d that will cause the reflections from both sides of the thin film to interfere *constructively*.

(c) (7 points) Solve as in (b) but for a general angle of incidence θ at the first interface (note that for $\theta = 0$ you should get the same answer as before).