UNIVERSITY OF CALIFORNIA AT BERKELEY

Physics 7C – (Stahler)

Spring 2017

FIRST MIDTERM

Please do all your work in your blue (or green) books. This printed exam is for you to keep, as are your notes on the single sheet of paper. On the cover page of your blue or green book, write your name, SID, discussion section number, and GSI name.

You must attempt all four problems. If you become stuck on one, go on to another and return to the first one later. Be sure to show all your reasoning clearly, i.e., do not simply write down equations. **Remember to circle your final answer!**

Problem 1 (30 points)

At noon in your town (not Berkeley), the sun is directly overhead on a certain day. Its measured intensity at ground level is $I_\circ = 1.00$ kW m^{-2}. You place on the ground a perfectly absorbing black square that is $L = 10$ cm on a side.

(a) Calculate numerically F, the force exerted on the plate by the solar radiation.

(b) Find $\bar{E}$, the average magnitude of the electric field in the sunlight. You may interpret this quantity as the rms value: $\bar{E} \equiv \langle E^2 \rangle^{1/2}$, where $\langle\ \rangle$ denotes a time average over many wave cycles.

A few hours later, the sun is at an angle $\theta = 60°$ above the horizon.

(c) What now is the radiative force on your black plate?

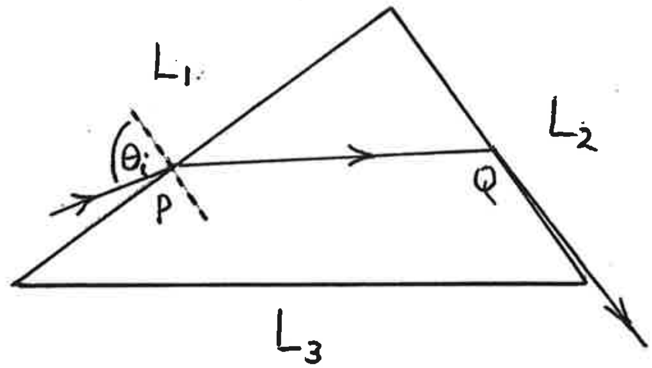
At this time, the sky is clear, although a rainstorm has just ended. Across town, where the weather is the same, your friend Joe calls to tell you excitedly that he is seeing a bright, primary rainbow.

(d) Is Joe's claim plausible or not? Whatever your answer, give a clear explanation, perhaps accompanied by a sketch if that would help.

Some possibly useful numbers are:

$c = 3.00 \times 10^8$ m s^{-1}
$\epsilon_\circ = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
$\mu_\circ = 1.26 \times 10^{-6}$ H m^{-1}

Problem 2 (15 points)



Light traveling through air enters the triangular prism shown at point P, with incident angle θ_i. The refracted portion of the light travels to point Q, where some is reflected (not shown) and some exits the prism at a grazing angle, i.e., the angle of refraction is nearly 90°. The sides of the prism have lengths: $L_1 = 4$ cm, $L_2 = 3$ cm, and $L_3 = 5$ cm.

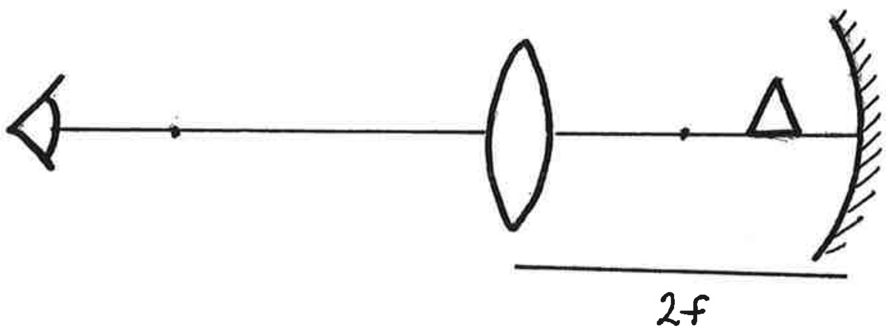
(a) Find an expression for θ_i in terms of n, the prism's index of refraction. Assume this quantity is exactly unity for air.

(b) If n is larger than some value n_{max}, no light from the incident ray can leave the prism through side L_2, regardless of the angle θ_i. What is n_{max}?

Problem 3 (30 points)

You are looking into a concave mirror, with focal length f. A small cone is at a distance $f/2$ in front of the mirror.

(a) Find the location and magnification (including algebraic sign) of the cone's mirror image.



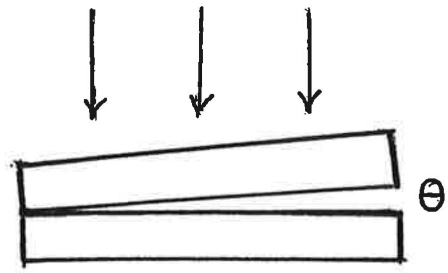
A converging lens, with focal length $2f$, is now placed a distance $2f$ in front of the mirror.

(b) Looking through this lens, how many images of the cone do you see? For each image, draw an appropriate (and *clear*) ray diagram.

(c) Are the images in (b) real or virtual? Justify your answers using the ray diagrams.

(d) Calculate the locations of all images you see through the lens. Express all distances with respect to the lens.

Problem 4 (25 points)



Two glass microscope slides ($n = 1.50$) touch at one end and are separated at the other end. The air between the slides ($n = 1.00$) acts as a thin film. When light of wavelength $\lambda = 480$ nm shines vertically downward on the slides, an overhead observer sees an interference pattern, with dark fringes separated by $d = 1.2$ mm.

(a) What is θ, the angle between the two slides?

(b) Consider the hinge, the place where the two slides touch. Is this an interference minimum (dark) or maximum (bright)? Explain your answer qualitatively.

(c) Suppose you replace the top slide with one twice as thick. Assuming the angle θ is unchanged from what you found in (a), what now is the spacing between dark fringes? Be sure to justify your answer.