Physics 7C, Speliotopoulos
First Midterm, Spring 2012
Berkeley, CA

Rules: *This midterm is closed book and closed notes. You are allowed two sides of one-half sheet of 8.5" x 11" of paper on which you may write whatever you wish. You are also allowed to use scientific calculators in general, but not ones which can communicate with other calculators through any means, nor ones that can do symbolic integration.* ***Anyone who does use a wireless-capable device will automatically receive a zero for this midterm.*** *Cell phones must be turned off during the exam, and placed in your backpacks.* ***In particular, cell-phone-based calculators cannot be used.***

Please make sure that you do the following during the midterm:

- ***Show all your work in your blue book***
- *Write your name, discussion number, ID number on all documents you hand in.*
- *Make sure that the grader knows what s/he should grade by circling your final answer.*
- *Cross out any parts of the your solutions that you do not want the grader to grade.*

Each problem is worth 20 points. We will give partial credit on this midterm*, so if you are not altogether sure how to do a problem, or if you do not have time to complete a problem, be sure to write down as much information as you can on the problem. This includes any or all of the following: Drawing a clear diagram of the problem, telling us how you would do the problem if you had the time, telling us why you believe (in terms of physics) the answer you got to a problem is incorrect, and telling us how you would mathematically solve an equation or set of equations once the physics is given and the equations have been derived. Don't get too bogged down in the mathematics; we are looking to see how much physics you know, not how well you can solve math problems.*

If at any point in the exam you have any questions, just raise your hand, and we will see if we are able to answer them.

Copy and fill in the following information on the front of your bluebook:

Name: ______________________________ *Disc Sec Number:* ______________________

Signature: ___________________________ *Disc Sec GSI:* _________________________

Student ID Number: ____________________

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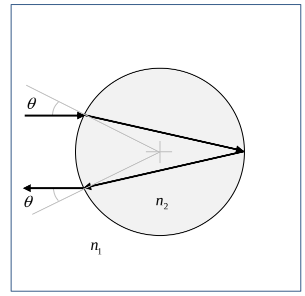
1. In the Sci Fi classic, "The Mote in God's Eye," the Moties sends a spacecraft using a solar sail to their nearest neighboring star by firing a huge bank of lasers to fire light beams at the sail. The pressure from these lasers is supposed to propel the spacecraft to the star. Take the mass of the Motie ship as 417,289 kg, and the area of the solar sail to be 9 km^2.
   a. If the lasers are to accelerate the spacecraft at a hundredth of g (0.098 m/s^2), what must be the total intensity of the lasers be? Assume that 99.8% of the light from the lasers are reflected by the sails, while 0.2% of the light is absorbed.
   b. What are the RMS amplitude of the electric and magnetic fields of the lasers?



2. A glass sphere, with index of refraction, n_2, is embedded in a material with index of refraction, n_1. What must the ratio, n_2/n_1, be such that a ray of light incident the sphere at angle, $\theta \ll 1$, is eventually reflected backwards by the sphere (see figure on right). Make use of small angle approximations.

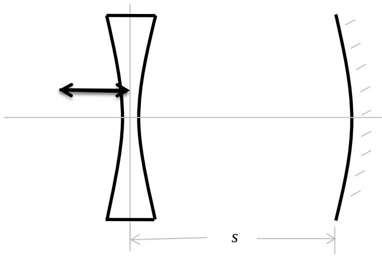


Figure A

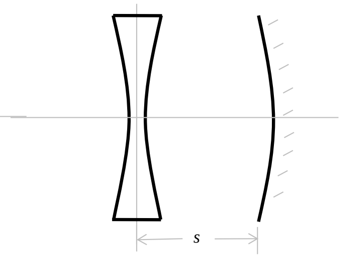
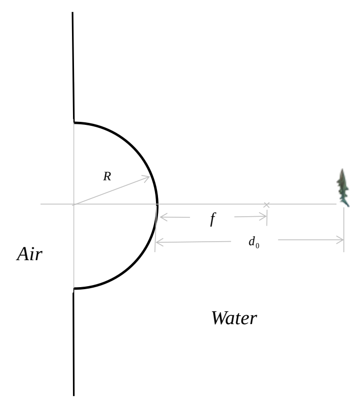


Figure B

3. A diverging lens with focal length, f_D, is placed in front of a convex, reflective mirror such that they are separated by a distance, s.
   a. When $s = |f_D|$, any incoming light parallel to the principle axis is reflected directly backwards (see Figure A below). What is the focal length, f_M, of the convex mirror?
   b. The separation is now reduced to $s = \frac{1}{2}|f_D|$. What is the position of the image, d_i, of an object placed a distance, $d_0 = 2|f_D|$, to the left of the centerline of the diverging lens? What is the orientation of the image relative to the orientation of the object?

4. The Kelp Forest at the Monterey Bay Aquarium is a large aquarium with a small alcove on the side of it. This alcove is made using a concave hemisphere of plastic with radius, *R*, and serves as a diverging lens (see figure on right). Assume that the index of refraction of the plastic is the same as water, *n*.
   a. Calculate the focal length, *f*, of the lens in terms of the radius, *R*, and the index of refraction, *n*, of water.
   b. What is the lateral magnification, *m*, of a fish at a distance, d_0, for the lens?



5. A glass disk with the parabolic profile,

$$y = \frac{x^2}{2r},$$

is placed on top of a flat piece of glass (see figure below). Both pieces of glass are submerge in a liquid with index of refraction, *n*, which is greater than the glass. Newton's rings are seen. For which radii, x_{max}, will bright rings be seen when viewed directly from above given a wavelength, λ, of the light in air? Answer in terms of *r*, λ, and a non-negative integer, *m*.