Physics 7C, Spring 2014 Instructor: Professor Adrian Lee
Midterm Examination, Tuesday, February 25, 2014

Please do work in your blue/greenbooks. Show your reasoning carefully so that we can be sure that you derived the answer rather than guessing it or relying on memory; in addition, this enables us to give partial credit. You may use one double-sided 3.5 x 5 index cards of notes. You can use a simple calculator (no smart phones or devices that can store notes). Test duration is 110 minutes.

1 Qualitative Questions [30 pts. total]

Only a few lines of explanation is needed for these. You don't have to use cartoons or equations, unless specified, but you can. No derivations are needed.

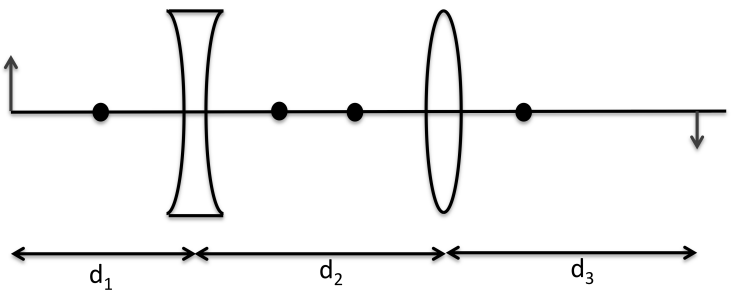
a) If you have a bare optical fiber made of glass ($n = 1.2$), can you get total internal reflection with the fiber in water (n = 1.33)? [5 pts.]

b) If a concave spherical mirror produces a real image, can it be upright only, inverted only, or both compared to the original object? You probably need ray diagram(s) for this question. [5 pts.]

c) For an electric field $E = E_0 sin(kx - \omega t)\hat{y}$ what is its velocity include the correct sign? [5pts.]

d) If you reverse a lens (flip it around the vertical), does it act the same and have the same focal length? [5 pts]

2 Reimaging System [30 pts. total]



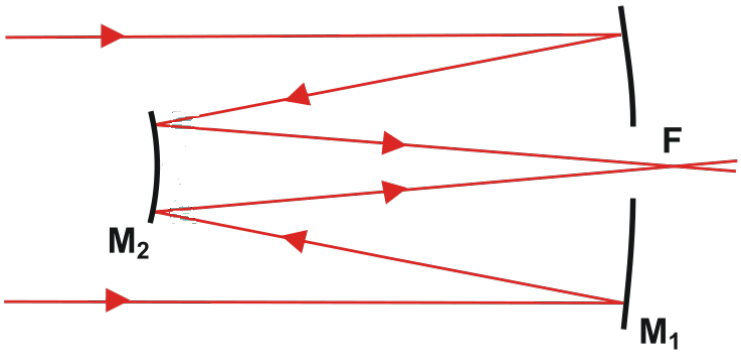
A small arrow is a distance d_1 from a diverging lens as shown in the figure. A converging lens with a focal length f_c is a distance d_2 to the right of the diverging lens with a focal length f_d. The two lens system forms a real inverted image a distance d_3 to the right of the converging lens. You should assume that $d_2 > f_c$, $d_2 > f_d$ and $d_2 > |f_c| + |f_d|$.

a) Draw a ray diagram [10 pts.]

b) Find an expression for the focal length of the diverging lens f_d in terms of d_1, d_2, d_3 and f_c. [10 pts.]

c) What is the magnification of the optical system? You can use any of the variables in the problem f_d, f_c, d_1, d_2 and d_3 [10 pts.]

3 Space Telescope [30 pts. total]



A telescope for space observations consists of two spherical mirrors arranged as shown in the figure. The large primary and small secondary mirrors have radii equal to R and r respectively. The distance between the mirrors is D and $D < R/2$. You can also assume that the secondary mirror is positioned such that the final image is formed as shown in the figure. This telescope design is called a "Maksutov Cassegrain."

a) Make a ray diagram showing where the final image is for an object at d_o = infinity. Is the image of the primary real or virtual? Is the object for the secondary real or virtual? [15 pts.]

b) What is the distance from the primary mirror to the final image? [15 pts.]

4 Solar Sail [30 pts. total]

A small perfectly reflecting sail of area A is a distance D away from the sun, with $A << D^2$. The amount of energy absorbed by the sail during a time interval T is measured to be U_{abs}. In terms of these quantities, please answer the following:

a) What is the amplitude of the electric field incident on the sail coming from the sun, E_0? [10 pts.]

b) What is the power output of the sun, assuming it radiates uniformly in all directions? [10 pts.]

c) In some coordinate system, the electric field incident on the sail can be written $E_{in} = E_0 sin(kx - \omega t)\hat{y}$. Write the magnetic field in terms of these quantities. [10 pts.]

d) In this same coordinate system, what possible directions could the electric field have been pointing if it was not pointing in the $\hat{y}$ direction? The propagation direction can not change. Possibilities include the $\hat{x}$ and/or $\hat{z}$ directions. [5 pts.]

e) Could the electric field be written $E_{in} = E_0 sin(kx - \omega t^2)y$? [5 pts.]