Physics 7C, Spring 2007, Section 2, Instructor: Prof. Adrian Lee
First Midterm Examination, Tuesday February 20, 2007

Please do work in your bluebooks. You may use one double-sided 3.5" x 5" index card of notes. Test duration is 120 minutes.

1a) (20 points total) In class, we derived the equations:

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t} \quad and \quad -\frac{\partial B}{\partial x} = \mu_0 \varepsilon_0 \frac{\partial E}{\partial t}$$ from Maxwell's Equations.

Starting from these, show that E(x,t) and B(x,t) obey the "wave equations,"

$$\frac{\partial^2 E}{\partial t^2} = v^2 \frac{\partial^2 E}{\partial x^2} \quad and \quad \frac{\partial^2 B}{\partial t^2} = v^2 \frac{\partial^2 B}{\partial x^2}$$

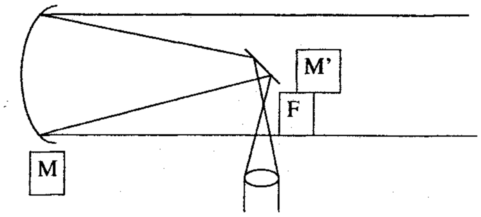
and give an expression for the velocity v as a function of μ_0 and ε_0 (10 points).

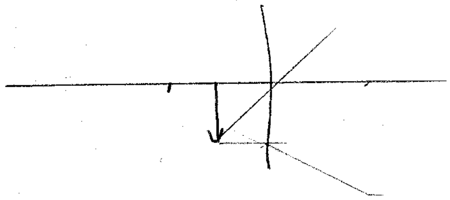
b) Give an example of a function of both $k = 2\pi/\lambda$ and $\omega = 2\pi f$ that satisfies this equation. Using your function and the wave equation, show the relation between k, ω, and the velocity. What is the direction of propagation of your solution? (10 points)

2a) (40 points total) Show that a thin converging lens of focal length f followed by a thin diverging lens of focal length –f will bring parallel light to a focus beyond the second (diverging) lens provided that the separation of the lenses L satisfies $0 < L < f$. (20 points)

b) Does the range L to get a focus change if the lenses are interchanged? (10 points)

c) What happens when $L = 0$ in both cases? (10 points)



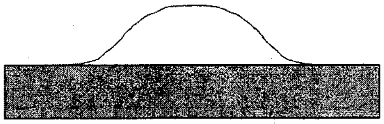


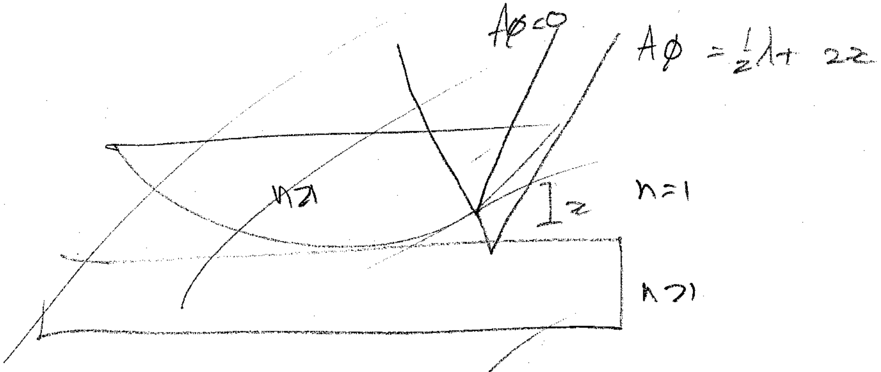
3) (40 points total) Isaac Newton invented the reflecting telescope sketched above. Parallel light falls onto the objective mirror M. After reflection from a small flat mirror M', the rays form a real inverted image in the focal plane F. This image is then viewed in an eyepiece. (Hint: draw an equivalent two-lens system and ignore the flat mirror)

a) Show that the angular magnification is given by $m_\theta = -f_{ob}/f_{eye}$, where f_{ob} and f_{eye} are the focal lengths of the objective and eyepiece respectively.

b) The Mt. Palomar 200" telescope has an objective focal length of 16.8 meter. Estimate the size of the image in the focal plane when the object is a meter stick 2 km away. You can assume the rays coming in are parallel.

c) Consider another telescope that has an objective with a radius of curvature of 10m (even though the mirror is parabolic, you can define an effective spherical radius). To get an angular magnification of -200 what is the focal length of the eyepiece?





4) An oil drop (n = 1.2) floats on a water (n =1.33) surface and is observed from above by reflected light.

a) Will the outer (thinnest) regions of the drop correspond to a bright or dark region? Show your reasoning. (15 pts)

b) How thick is the oil film where one observes the third blue ($\lambda = 475$ nm) region from the outside of the drop? (15 pts)

c) Why do the colors gradually disappear as the oil thickness becomes larger? (10 pts)