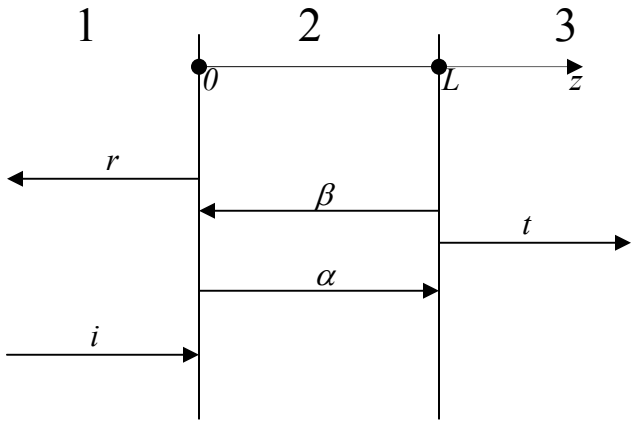
ECE 278
Homework #1
Due Jan. 15, 2002, at the beginning of class

1) (10 pts.) Verdeyen problem 1.5
2) (10 pts.) Photons:
   A) What is the typical power consumed by a light bulb? If all of the energy from the wall plug went into creating optical photons, roughly how many photons per second would be created?
   B) The energy flow from sunlight at the surface of the earth is about 1000 W/m^2. The distance from the Earth to the sun is about 10^{11} m. Roughly how many photons per second are generated by the sun?
3) (10 pts.) In class, we claimed that $\vec{\nabla}\cdot\vec{b}=0$ is a "law" of physics. Sketch a vector field $\vec{b}$ that violates this condition. Such a field has never been observed in nature.
4) (50 pts.) A plane wave traveling in a medium of impedance Z_1 is normally incident at z=0 on a second medium of impedance Z_2. The second medium has thickness L and behind it is another medium of impedance Z_3, which occupies the rest of space.
   A) Show that the ratio of the reflected and incident electric field amplitudes in the incident medium is given by
   $$\frac{E_r}{E_i}=\frac{Z_2(Z_3-Z_1)\cos(k_2L)-i(Z_2^2-Z_1Z_3)\sin(k_2L)}{Z_2(Z_3+Z_1)\cos(k_2L)-i(Z_2^2+Z_1Z_3)\sin(k_2L)}$$
   (You will need the five *resultant* waves indicated, that is, the situation is in its final steady state. Remember: the boundary conditions must be satisfied at both boundaries simultaneously.)
   B) Show that if $Z_1 \neq Z_3$, the reflected wave will be zero when L equals an odd multiple of a quarter wavelength in medium 2 and $Z_2 = (Z_1 Z_3)^{1/2}$.
   C) Find the corresponding conditions for zero reflected wave when $Z_1 = Z_3 \neq Z_2$.
   D) Red light is normally incident in a vacuum upon a large slab of nonmagnetic glass of index of refraction 1.5. If the glass is to be coated with a layer of nonmagnetic material in order that the light not be reflected, find the required index of refraction and minimum thickness of the coating.
   E) Is E_r/E_i ever = 1? If so, when?
   F) Assume medium 2 is glass (n_2=1.5) and medium 1,3 are vacuum (n_1=n_3=1). *Sketch* the transmitted power vs. frequency. Hint: The power reflected is $|E_r/E_i|^2$, and the transmitted power is $1-|E_r/E_i|^2$. How would the plot change if medium 2 was GaAs?



5) (10 pts.) In class we derived the wave equation for e. Derive the wave equation for b: $\nabla^2\vec{b}=\mu_0\varepsilon_0\frac{\partial^2}{\partial t^2}\vec{b}$
6) (10 pts.) Prove the boundary conditions Verdeyen eqns. 1.9.1 a-d. Hint: Start from Maxwell's equations, and then use the Stoke's theorem and Gauss' theorem.