PHY103, Problem set-7 Date: April 14, 2015 [DpC]

1. The power density in sunlight, at the earth, is roughly $1kW/m^2$. How large are the electric and magnetic field strengths? What pressures does it exert on a perfect absorber and a perfect reflector?

2. A plane EM wave traveling in air ($\mu_r = 1, \epsilon_r = 1$) has $\vec{\tilde{E}} = 10(V/m)e^{i(4x-3z-\omega t)}\hat{y}$. The wave falls on a dielectric medium with $\epsilon_r = 1.44(\mu_r \sim 1)$ at $z = 0$ (the surface of the medium is in x-y plane).
   (a) Find the wavelength and angular frequency of the incident wave.
   (b) Find the expression for the electric field of the reflected wave.
   (c) Find the expression for the electric and the magnetic fields of the transmitted wave.

3. A light wave is incident on crown glass ($n = 1.52$) at an angle $\theta = \pi/6$. Determine the amplitude reflection and transmission coefficients (i.e., E_{0R}/E_{0I} and E_{0T}/E_{0I}) when the beam is linearly polarized in the plane of incidence. Determine the angle at which the reflected wave would be completely extinguished.

4. Show that the skin depth in a poor conductor ($\sigma << \omega\epsilon$) is $(2/\sigma)\sqrt{\epsilon/\mu}$. Calculate the skin depth of water.

5. Consider a plane wave of frequency ω traveling in a conducting medium of conductivity σ. The electric field is found to be given by $\vec{E} = E_0\ Re[E^{i(kx-\omega t)}]\hat{y}$, where $k^2 = i\mu_0\sigma\omega$.
   (i) Find $\vec{B}$.
   (ii) Find the phase difference between $\vec{E}$ and $\vec{B}$.
   (iii) Find the contribution of $\vec{E}$ and $\vec{B}$ to the energy density. Which contribution dominates for $\frac{\sigma}{\epsilon\omega} \gg 1$.