NNSE 508 EM

Home assignment # 3 **Due: February 24, 2014**

1. For a normal incidence of plane monochromatic EM wave from a medium with impedance η_1 to a medium with impedance η_2,
a) write the wave phasors (electric and magnetic fields) for incident, transmitted and reflected waves. Note: pay specific attention to relationships between signs that can be obtained from Maxwell equations.
b) Applying boundary conditions show that reflection and transmission coefficients are as follows:

$$\mathbf{E}_{1tan} = \mathbf{E}_{2tan}$$
$$\mathbf{H}_{1tan} = \mathbf{H}_{2tan}$$
$$\mathbf{D}_{1norm} = \mathbf{D}_{2norm}$$
$$\mathbf{B}_{1norm} = \mathbf{B}_{2norm}$$

$$r = \frac{E_r}{E_i} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} \qquad t = \frac{E_t}{E_i} = \frac{2\eta_2}{\eta_2 + \eta_1} = 1 + r$$

2. Electromagnetic radiation loses intensity when it reflects from surfaces with roughness greater than the wavelength λ. Assuming you would like to use the lowest energy source possible, determine the frequencies of EM waves which would be appropriate to characterize
(a) cars on a road
(b) the presence of mountains
(c) micron-size voids in insulators
(d) atomic steps on a single crystal
and identify the types of EM waves present in each case (e.g. cosmic waves, UV, visible, etc.)

4. The dispersion relationship for lattice vibrations is $\omega^2 = \frac{2K}{M}(1 - \cos ka)$, where *a* is the lattice constant, M is the atomic mass, and K is an effective interatomic interaction (spring) constant. Sketch the dispersion relationship and derive an expression for the group velocity.

5. Show that at low frequencies (f < 10^{13} Hz) the reflectivity and conductivity of metals are related by Hugen-Rubens equation: $R = 1 - 4\sqrt{\frac{f}{\sigma}\pi\varepsilon_0}$. Confirm that at these frequencies metals can be treated as "good conductors".

6. Assuming that in alkali metals each atom provides one free electron, find in all alkali metals:
a) electron density;
b) electron mean free path at 300K;
c) scattering time
Given:

Metal	Li	Na	K	Rb	Cs
Density, g/cm^3	0.525	0.961	0.850	1.52	1.89
Specific resistivity μΩ-cm	8.6	4.2	6.15	12.5	20