EE 301 Tutorial 3 21/8/19

1. Given electrical field intensity in free space $\hat{E} = 50\hat{x}\cos(10^5 t - 10^5\sqrt{\mu_o \varepsilon_o}\, z)$ (V/m) Compute speed of propagation, frequency, amplitude and direction of propagation of wave
2. $\nabla^2 A = \mu\varepsilon\frac{\partial^2 A}{\partial t^2}$ is wave equation in terms of magnetic vector potential, express it in terms of electric flux density D
3. A electric field in a lossless medium with $\varepsilon_r = 9$ and $\mu_r = 1$, and wave travels in x-y plane at an angle 30° to the x-axis and frequency = 50MHz and E_o = 10V/m. Find phasor equation of the wave
4. A AM radio station transmits at 2MHz with amplitude of electric field intensity as 10V/m. Find-
   a. Magnetic field intensity
   b. Electric and magnetic field intensity in time domain (Mention any assumption you made for the same)
   c. ε_r changes from 1.0 to 2.0, calculate change in phase velocity, intrinsic impedance and magnetic field intensity assuming amplitude of electric field does not change
5. The electric field density of a plane EM wave is $\hat{E}(z) = \hat{x}8\cos(10^6\pi t)$ V/m at the point x=0, y=0, z=0. The magnetic field intensity is in the positive y direction and the wave propagates in a material with properties $\varepsilon = \varepsilon_o$ [F/m], $\mu = \mu_o$ [H/m], and $\sigma = 1.5*10^{-5}$ S/m. Find the magnetic field intensity at a distance 1km from origin in direction of propagation
6. A satellite at the height of 30,000km above the Earth's surface communicates at 30GHz and assume that the atmosphere is 15km thick (assume free space above it). Properties of the atmosphere are $\varepsilon = 1.5\varepsilon_o$ [F/m], $\mu = \mu_o$ [F/m], and $\sigma = 10^{-6}$ S/m:
   a. Calculate phase velocity, propagation constant, intrinsic impedance in atmosphere and free space
   b. If minimum electric field intensity required for reception is 10mV/m then what is the minimum amplitude of transmitter on Earths' surface, assuming satellite completely reflects the signal
7. A room of aluminum walls aims at attenuating electric field of minimum frequency 1Mhz by a factor of 10^6 given its conductivity is $3.7x10^7$ S/m what should be the wall thickness. If instead we use iron walls with conductivity 10^7 S/m and relative permeability 100 then what will be the wall thickness
8. A circular cable(r=0.1m) made of iron carries an AC current at 100Hz. If the maximum current density allowed is 100A/mm2, find the current density at the center of the cable and the total current flowing through the cable ($\sigma = 10^7 S/m, \mu = 20\mu_o$) (Hint: Assume exponential decay of current density)

9. The electric field for a linearly polarized electromagnetic wave propagating in free space is given by $\hat{E} = \hat{n}E_0\exp[i(\omega t-2x+4y-4z)]$ where x,y,z are in meters and t in sec, and $\hat{n}=\frac{1}{\sqrt{18}}[4\hat{x}+\hat{y}-\hat{z}]$ represents unit vector along $\hat{E}$

   a. What is wavelength and frequency of the wave?

   b. Obtain unit vector along direction of propagation of wave

   c. Is the wave transverse?

10. Suppose a submarine communicates with another submarine in sea water, and ratio between amplitude at receiver and transmitter must be greater than 10^{-12} then what is maximum range of communication (given relative permittivity is 72 and conductivity is 4S/m) at:

   a. 10MHz

   b. 100Hz

Review Questions:

1. Does wavelength or frequency change for a propagating wave if medium changes? Why?
2. Is polarization possible in longitudinal waves?