NTHU Electrical Engineering Department
EE3360 Optoelectronic Devices Spring 2019
HW #1

1. (a) Starting from the source free Maxwell's equations, derive the associated wave equations for $\vec{H}$. (b) Verify directly that the expression for the electric field intensity of a uniform plane EM wave propagating in free space is the solution of wave equation.

2. The wave equations for $\vec{E}$ and $\vec{H}$ are derived from Maxwell's equations. However, whereas every solution to Maxwell's equations must obey the wave equation, the converse is not true. Please start from the solutions of wave equations for $\vec{E}$ and $\vec{H}$ and show what are the extra constraints imposed by Maxwell's equations on the x, y, z components of $\vec{E}$ and $\vec{H}$, assuming the EM wave propagating in z direction.

3. The solution of wave equation has the form of $E = E_0 \cos(\omega t - kz + \phi)$. Please find out the velocity of the wave by tracing the speed of the wavefront.

4. Consider the following vectors:

$$\vec{E}_1 = \hat{a}_z e^{-jkz}$$
$$\vec{E}_2 = (\hat{a}_x + j\hat{a}_z)e^{-jky}$$
$$\vec{E}_3 = (\hat{a}_x + \hat{a}_z)e^{-jk(x-z)/\sqrt{2}}$$

   (a) Electromagnetic waves satisfy Maxwell's equations. Please determine which of the above vectors represent electromagnetic waves. For those which do not, please explain the reason by specifying which of Maxwell's equations are violated.
   (b) Please determine the magnetic field $\vec{H}$ (in vacuum) in phasor notation for those which represent EM waves.
   (c) From (b), please give the corresponding real time expression for both $\vec{E}$ and $\vec{H}$ for those which represent EM waves.

5. The electric field of an EM wave propagating through a simple material is given by

$$\vec{E} = 10\cos(10^8 t + y)\hat{a}_z \text{ V/m} \quad \text{(t in s; y in m)}$$

   Please find
   (a) the direction of propagation, time period, wavelength, and phase velocity of the wave
   (b) the relative permittivity of the material
   (c) the instantaneous magnetic field intensity vector and the phasor notation for both electric $\vec{E}$ and magnetic field $\vec{H}$ vectors of the wave.

6. A uniform plane wave of frequency f=300 MHz propagating in the direction defined by the vector $\hat{a}_x + \hat{a}_y$. The electric field vector of the wave at the coordinate origin is $\vec{E}_0 = (1+j)\hat{a}_z$ V/m, and the medium is air. Please find (a) the phasor expressions for electric and magnetic field vectors of the wave at an arbitrary point in space, and (b) the instantaneous expression of the electric field specifically for x=10m, y=1m, and z=5m.