1. (a) (8%) What is Poynting's theorem?
   (b) (8%) What is Helmholtz theorem?
   (c) (5%) What is the intrinsic impedance of a material medium for the electromagnetic wave?
   (d) (5%) What is the loss tangent of a material medium for the electromagnetic wave?
   (e) (10%) Write down the boundary conditions of electromagnetic waves propagating through the interface between two arbitrary media?

2. (14%) Charge is distributed with uniform density ρ_0 C/m^3 in the spherical region $r<a$. Find the electric displacement field $\bar{D}$ everywhere.

3. (14%) Consider two electric fields given by

$$\bar{E}_1 = (C\bar{a}_x + C\bar{a}_y + \bar{a}_z)\cos(10^9 t - 10z) \text{ V/m}$$
$$\bar{E}_2 = (\bar{a}_x + C\bar{a}_y - 2\bar{a}_z)\sin(10^9 t - 10z) \text{ V/m}$$

   (a) Find the polarization of $\bar{E}_1 + \bar{E}_2$ for C=2.
   (b) Find the value of C for which $\bar{E}_1 + \bar{E}_2$ is circularly polarized.

4. (16%) Region 1 (z<0) is free space, whereas region 2 (z>0) is a perfect dielectric medium characterized by $\varepsilon=4\varepsilon_0$, $\mu=\mu_0$. For a uniform plane wave having the electric field

$$\bar{E} = E_0 \cos(3\times10^8 t - z)\bar{a}_x$$

   normal incident on the interface z=0 from region 1, obtain the expression for the reflected and the transmitted electric fields.

5. (20%) The electric field of a uniform plane wave propagating in a perfect dielectric medium having $\mu = \mu_0$ is given by

$$\bar{E} = 10\cos(3\times10^7 t + 0.2x)\bar{a}_z \text{ V/m}$$

   (a) Find the phase velocity.
   (b) Find the permittivity of the medium.
   (c) Find the associated magnetic field $\bar{H}$.
   (b) Find the time-average Poynting vector.

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