

1. (18%) The electric field of a uniform plane wave is given by

$$\vec{E} = E_0 \cos(\omega t - \beta z) \vec{a}_x + 3E_0 \sin(\omega t - \beta z) \vec{a}_y, \text{ V/m}$$

- (a) Find the associated magnetic field \vec{H} .
(b) Find the instantaneous Poynting vector.
(c) Find the time-average Poynting vector.
2. (20%) Consider current I flows from $z=-\infty$ to a point charge $Q(t)$ located at the origin along a infinitely long straight wire on z -axis. Current $0.2I$ flows from the point charge $Q(t)$ to $z=\infty$ along the wire on z -axis. Find the line integral of \vec{H} along a circular path of radius a lying in the xy -plane and centered at the point charge.
3. (20%) An isotropic dielectric material is characterized by

$$\begin{Bmatrix} D_x \\ D_y \\ D_z \end{Bmatrix} = \begin{bmatrix} \epsilon_{xx} & \epsilon_{xy} & 0 \\ \epsilon_{yx} & \epsilon_{yy} & 0 \\ 0 & 0 & \epsilon_{zz} \end{bmatrix} \begin{Bmatrix} E_x \\ E_y \\ E_z \end{Bmatrix}$$

For $\vec{E} = E_x \vec{a}_x + E_y \vec{a}_y$, find the value of E_y/E_x for which \vec{D} is parallel to \vec{E} . Find the corresponding effective permittivity for the case.

4. (20%) An infinite plane sheet lying in the $z=0$ plane carries a surface current of density

$$\vec{J}_s = \cos(6\pi \times 10^8 t) \vec{a}_x \text{ A/m}$$

Region 1 ($z>0$) is free space, whereas region 2 ($z<0$) is a perfect dielectric of $\epsilon=4\epsilon_0$, $\mu=\mu_0$. Find the electric and magnetic fields in each region.

5. (22%)
- (a) (5%) Briefly describe the phenomenon of polarization in a dielectric material.
- (b) (5%) What is the skin effect of a material medium for the electromagnetic wave?
- (c) (6%) What is displacement current? What is different between displacement current with current due to flow of charge?
- (d) (6%) What is the domain and domain wall motion in a material?