Problem – Supplementary Problem 4 In a material of non-zero electrical resisitivity ρ, the relationship between electric field and current density is $\mathbf{E} = \rho \mathbf{j}$. For copper, $\rho = 2 \times 10^{-8} \Omega m$. A copper wire with a circular cross-sectional area of 4 mm^2 carries a current of 40 A.

a) What is the longitudinal electric field (field along the length of the wire) in the copper?

b) If the current is changing at a rate of 5000 A/s, at what rate is **E** changing, and what is the resulting displacement current?

c) Does the displacement current contribute significantly to the magnetic field outside the wire? Explain your answer.

Solution:

Problem – (E38.16)* The electric field associated with a plane electromagnetic wave is given by $E_x = 0, E_y = 0, E_z = E_0 \sin k(x - ct)$, where $E_0 = 2.34 \times 10^{-4}$ V/m and $k = 9.72 \times 10^6$/m. The wave is propagating in the $+x$ direction.

a) Write expressions for the components of the magnetic field of the wave.

b) Find the wavelength of the wave.

Solution:

Problem – Supplementary Problem 5

a) Consider an electromagnetic wave in a vacuum with electric field $\mathbf{E} = E_0\hat{\mathbf{y}}\sin(kx - \omega t)$. What is the propagation direction of this electromagnetic wave?

b) Consider an electromagnetic wave with electric field $\mathbf{E} = E_0\hat{\mathbf{y}}\sin(kx + \omega t)$. What is the propagation direction of this electromagnetic wave?

c) Consider the electric field $\mathbf{E} = E_0\hat{\mathbf{y}}[\sin(kx - \omega t) + \sin(kx + \omega t)]$. Show that this electric field satisfies the wave equation

$$\frac{\partial^2 \mathbf{E}}{\partial x^2} + \frac{\partial^2 \mathbf{E}}{\partial y^2} + \frac{\partial^2 \mathbf{E}}{\partial z^2} = \frac{1}{V^2}\frac{\partial^2 \mathbf{E}}{\partial t^2},$$

provided the constants k and ω are related as in part (a).

Solution:

Problem – ¶(P38.5) ***(3 points)*** A cube of edge a has its edges parallel to the x, y, and z axes of a rectangular coordinate system. A uniform electric field **E** is parallel to the y axis and a uniform magnetic field **B** is parallel to the x axis. Calculate

a) the rate at which, according to the Poynting vector point of view, energy may be said to pass through each face of the cube and

b) the net rate at which the energy stored in the cube may be said to change.

Solution:

Problem – ¶(E38.22) ***(2 points)*** A plane electromagnetic wave is traveling in the negative y direction. At a particular position and time, the magnetic field is along the positive z axis and has a magnitude of 28 nT. What are the direction and magnitude of the electric field at that position and at that time?

Solution:

Problem – ¶(P38.13) A plane electromagnetic wave, with wavelength 3.18 m, travels in free space in the $+x$ direction with its electric vector $\mathbf{E}$, of amplitude 288 V/m, directed along the y axis.

a) What is the frequency of the wave?

b) What is the direction and amplitude of the magnetic field associated with the wave?

c) If $\mathbf{E} = E_m \sin(kx - \omega t)$, what are the values of k and ω?

d) Find the intensity of the wave.

e) If the wave falls on a perfectly absorbing sheet of area $1.85\ \mathrm{m}^2$, at what rate would momentum be delivered to the sheet and what is the radiation pressure exerted on the sheet?

Solution: