ELECTROMAGNETICS THEORY
BEKP3553
1-2006/2007

Tutorial 5:

A. Maxwell's Equations for Time-Varying Fields

1. In what ways are **E** and **B** related in a conducting medium under static condition.

2. State Lenz's law

3. Write the expression for transformer emf.

4. Why are materials having high permeability and low conductivity preferred as transformer cores?

5. Write the general forms of Faraday's law.

6. Why are the cores of power transformers laminated?

7. The loop below is in the *x*-*y* plane and $\mathbf{B} = \hat{\mathbf{z}} B_0 \sin \omega t$ with B_o positive. What is the direction of I ($\hat{\phi}$ or $-\hat{\phi}$) at:

   (a) $t = 0$
   (b) $\omega t = \pi/4$
   (c) $\omega t = \pi/2$

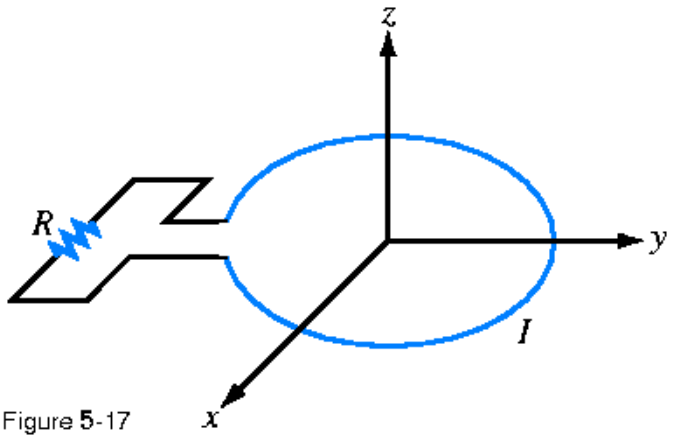


Figure 5-17

8. A coil consists of 100 turns of wire wrapped around a square frame of sides 0.25m. The coil is centered at the origin with each of its sides parallel to the *x*- or *y*-axis. Find the induced emf across the open-circuited ends of coil if the magnetic field is given by

   (a) $\mathbf{B} = \hat{\mathbf{z}}10e^{-2t}$ (T)

   (b) $\mathbf{B} = \hat{\mathbf{z}}10\cos x \cos 10^3 t$ (T)

B. Plane-Wave Propagation

9. The voltage of an electromagnetic wave traveling on a transmission line is given by

$$v(z,t) = 3e^{-\alpha z}\sin(2\pi \times 10^9 t - 10\pi z)$$

   where z is the distance in meters from the generator.

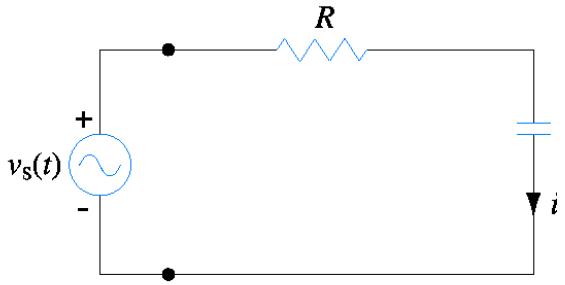
   (a) Find the following of the wave
   - (i) Frequency
   - (ii) Wavelength
   - (iii) Phase velocity

   (b) At z = 2 m, the amplitude of the wave was measured to be 1V. Find α.

10. A voltage source given by

$$v_s(t) = 10\cos(2\pi \times 10^3 t - 30^0) \quad \text{(V)}$$

   is connected to a series *RC* load as shown in the figure below. If R = 1 MΩ and C = 100 pF, obtain an expression for $v_c(t)$, the voltage across the resistor.



11. A series *RLC* circuit is connected to a generator with a voltage $v_s(t) = V_0 \cos(\omega t + \pi/3)$ (V).

    (a) Write the voltage loop equation in terms of the current $i(t)$, R, L, C and $v_s(t)$.
    (b) Obtain the corresponding phasor-domain equation.
    (c) Solve the equation to obtain an expression for the phasor current $\tilde{I}$.

12. The magnetic field of a wave propagating through a certain nonmagnetic material is given by

$$\mathbf{H} = \hat{\mathbf{z}} 50 \cos(10^9 t - 5y)$$

    Find the following:
    (a) The direction of wave propagation.
    (b) The phase velocity.
    (c) The wavelength in the material.
    (d) The relative permittivity of the material.
    (e) The electric field phasor.

13. The electric field phasor of a uniform plane wave is given by $\tilde{\mathbf{E}} = \hat{\mathbf{y}} 10 e^{j0.2z}$ (V/m). If the phase velocity of the wave is 1.5×10^8 m/s and the relative permeability of the medium is μ_r =2.4.

    Find the following:
    (a) The wavelength.
    (b) The frequency f of the wave.
    (c) The relative permittivity of the medium.
    (d) The magnetic field $\mathbf{H}(z,t)$.