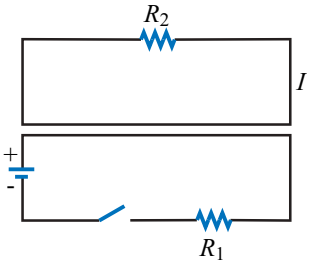
CMPE 330 Spring 2015 Problem Set #7

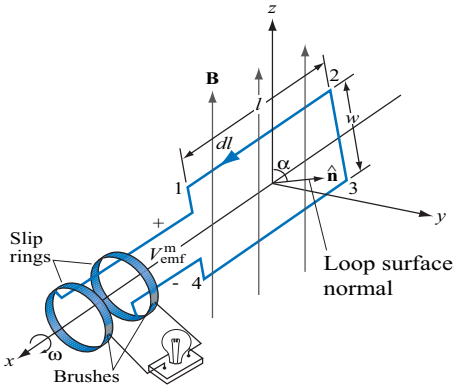
NOTE: You must show complete work for full credit. Report numerical solutions to two significant figures unless otherwise specified.

1. The switch in the bottom loop of the figure to the right [Ulaby et al., Fig. P6.1] is closed at $t = 0$ and then opened at a later time t_1. What is the direction of the current I in the top loop (clockwise or counterclockwise) at each of the two times. [Ulaby et al. 6.1, p. 308]

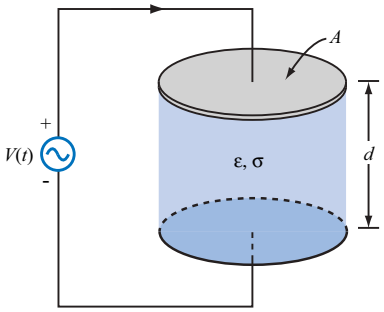


2. A circular-loop TV antenna with 0.02-m^2 area is in the presence of a uniform-amplitude 300-MHz signal. When oriented for maximum response, the loop develops an emf with a peak value of 20 mV. What is the peak magnitude **B** of the incident wave? [modified from Ulaby et al. 6.5, p. 309]

3. The electromagnetic generator shown in the accompanying figure [Ulaby et al., Fig. 6-12] is connected to an electric bulb with a resistance of 100 Ω. If the loop area is 0.1 m^2 and it rotates at 3,600 revolutions per minute in a uniform magnetic flux density $B_0 = 0.2$ T, determine the amplitude of the current generated in the light bulb. [modified from Ulaby et al. 6.12, p. 310]



4. The parallel-plate capacitor shown in the accompanying figure [Ulaby, Fig. P6.16] is filled with a lossy dielectric material of relative permittivity ϵ_r and conductivity σ. The separation between the plates is d and each plate is of area A. The capacitor is connected to a time-varying voltage source $V(t)$. [modified from Ulaby 6.16, p. 311]



   a. Obtain an expression for I_c, the conduction current flowing between the plates inside the capacitor, in terms of the given quantities.

   b. Obtain an expression for I_d, the displacement current flowing inside the capacitor.

   c. Based on the expressions for parts (a) and (b), give an equivalent-circuit representation for the capacitor.

d. Evaluate the values of the circuit elements for $A = 2$ cm^2, $d = 0.5$ cm, $\epsilon_r = 4$, $\sigma = 2.5$ S/m, and $V(t) = 10\cos(3\pi \times 10^3 t)$ V.

5. The magnetic field in a dielectric material with $\epsilon = 4\epsilon_0$, $\mu = \mu_0$, and $\sigma = 0$ is given by $\mathbf{H}(y,t) = \hat{\mathbf{x}}5\cos(2\pi \times 10^7 t + ky)$ A/m. Find the wavenumber k and the associated electric field E. [Ulaby 6.24, p. 312]

6. A Hertzian dipole is a short conducting wire carrying an approximately constant current over its length l. If such a dipole is placed along the z-axis with its midpoint at the origin, and if the current flowing through it is $i(t) = I_0 \cos \omega t$, find the following: [Ulaby 6.27, p. 312]

   a. The retarded potential $\tilde{\mathbf{A}}(R,\theta,\phi)$ at an observation point $Q(R,\theta,\phi)$ in a spherical system.

   b. The magnetic phasor $\tilde{\mathbf{H}}(R,\theta,\phi)$.

   Assume that l is sufficiently small so that the observation point is approximately equidistant to all points on the dipole; that is, assume $R' \simeq R$.