

Homework 5

You don't need to do P.5-6.

P.5-6 Lightning strikes a lossy dielectric sphere— $\epsilon = 1.2 \epsilon_0$, $\sigma = 10 \text{ (S/m)}$ —of radius 0.1 (m) at time $t = 0$, depositing uniformly in the sphere a total charge 1 (mC). Determine, for all t ,

- a) the electric field intensity both inside and outside the sphere,
- b) the current density in the sphere.

P.5-7 Refer to Problem P.5-6.

- a) Calculate the time it takes for the charge density in the sphere to diminish to 1% of its initial value.
- b) Calculate the change in the electrostatic energy stored in the sphere as the charge density diminishes from the initial value to 1% of its value. What happens to this energy?
- c) Determine the electrostatic energy stored in the space outside the sphere. Does this energy change with time?

P.5-10 The space between two parallel conducting plates each having an area S is filled with an inhomogeneous ohmic medium whose conductivity varies linearly from σ_1 at one plate ($y = 0$) to σ_2 at the other plate ($y = d$). A d-c voltage V_0 is applied across the plates as in Fig. 5-11. Determine

- a) the total resistance between the plates,
- b) the surface charge densities on the plates,
- c) the volume charge density and the total amount of charge between the plates.

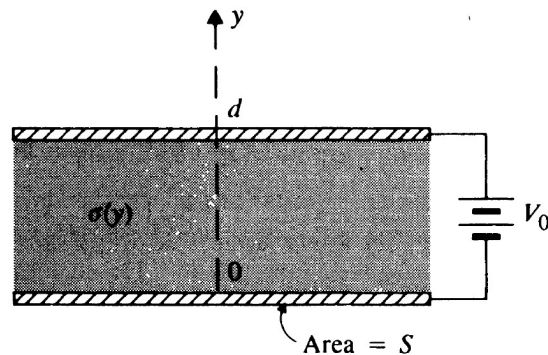


FIGURE 5-11
Inhomogeneous ohmic medium with conductivity $\sigma(y)$ (Problem P.5-10).

P.5-16 Determine the resistance between two concentric spherical surfaces of radii R_1 and R_2 ($R_1 < R_2$), assuming that a material of conductivity $\sigma = \sigma_0(1 + k/R)$ fills the space between them. (Note: Laplace's equation for V does not apply here.)

P.5-22 Assume a rectangular conducting sheet of conductivity σ , width a , and height b . A potential difference V_0 is applied to the side edges, as shown in Fig. 5-14. Find

- the potential distribution,
- the current density everywhere within the sheet. (*Hint*: Solve Laplace's equation in Cartesian coordinates subject to appropriate boundary conditions.)

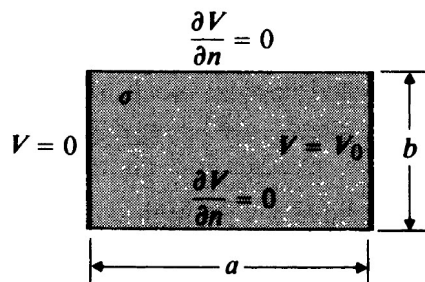


FIGURE 5-14

A conducting sheet (Problem P.5-22).

of the charge, and describe the path that the charge takes.

P.6-2 An electron is injected with a velocity $\mathbf{u}_0 = \mathbf{a}_y u_0$ into a region where both an electric field \mathbf{E} and a magnetic field \mathbf{B} exist. Describe the motion of the electron if

- $\mathbf{E} = \mathbf{a}_z E_0$ and $\mathbf{B} = \mathbf{a}_x B_0$,
- $\mathbf{E} = -\mathbf{a}_z E_0$ and $\mathbf{B} = -\mathbf{a}_z B_0$.

Discuss the effect of the relative magnitudes of E_0 and B_0 on the electron paths in parts (a) and (b).

P.6–12 Two identical coaxial coils, each of N turns and radius b , are separated by a distance d , as depicted in Fig. 6–39. A current I flows in each coil in the same direction.

- Find the magnetic flux density $\mathbf{B} = \mathbf{a}_x B_x$ at a point midway between the coils.
- Show that dB_x/dx vanishes at the midpoint.
- Find the relation between b and d such that $d^2 B_x/dx^2$ also vanishes at the midpoint.

Such a pair of coils are used to obtain an approximately uniform magnetic field in the midpoint region. They are known as *Helmholtz coils*.

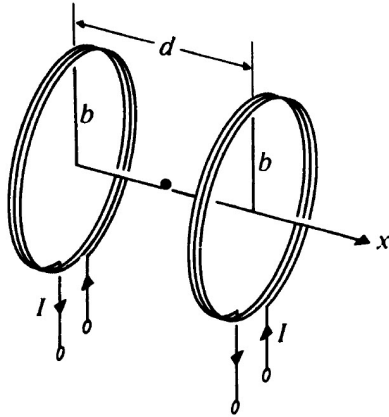


FIGURE 6–39
Helmholtz coils (Problems P.6–12).

P.6–24 Do the following by using Eq. (6–224):

- Determine the scalar magnetic potential at a point on the axis of a circular loop having a radius b and carrying a current I .
- Obtain the magnetic flux density \mathbf{B} from $-\mu_0 \nabla V_m$, and compare the result with Eq. (6–38).

$$V_m = -\frac{I}{4\pi} \Omega, \quad (6-224)$$

$$\mathbf{B} = \mathbf{a}_z \frac{\mu_0 I b^2}{2(z^2 + b^2)^{3/2}} \quad (\text{T}).$$

(6–38)

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