

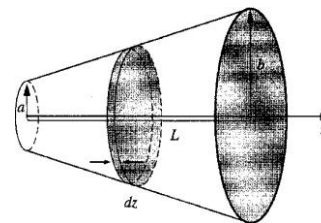
1. Find the self-inductance L of a solenoid(radius R , length l , current I , and n turns per unit length),

(a) Using the flux relation $\Phi = LI$.(10%)

(b) Using the energy relation $W = \frac{1}{2}LI^2$.(10%)

2. (a) Calculate the resistance of a conical shaped object, of resistivity ρ ,with length L , radius a at one end and radius b at the other. The two ends are flat, and are taken to be equipotentials. The suggest method is to slice it into circular disks of width dz , find the resistance of each disk, and integrate to get the total. Calculate R this way. (10%)

(b) Suppose the ends are, instead, spherical surfaces, centered at the apex of the cone. Calculate the resistance in this case. (Let L be the distance between the centers of the circular perimeters of the caps.) (10%)



3. (a) Consider two equal point charges q , separated by distance $2a$. Construct the plane equal-distant from the two charges. By integrating Maxwell's stress tensor over this plane, determine the force of one charge on the other. (10%)

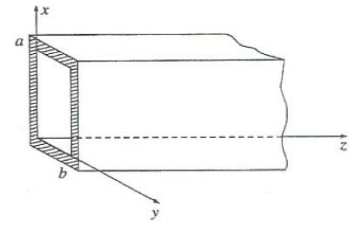
(b) Do the same for charges that are opposite in sign. (10%)

[Hint: $\mathbf{F} = \oint \mathbf{T} \cdot d\mathbf{a} - \epsilon_0 \mu_0 \int \mathbf{S} d\tau$ and $T_{ij} \equiv \epsilon_0 \left(E_i E_j - \frac{1}{2} \delta_{ij} E^2 \right) + \frac{1}{\mu_0} \left(B_i B_j - \frac{1}{2} \delta_{ij} B^2 \right)$]

4. A wave is propagating in a rectangular waveguide with fundamental TE_{10} mode.

$$B_z(x, z, t) = B_0 \cos(\pi x/a) \cos(kz - \omega t) .$$

- (a) Find E_x , E_y , B_x , and B_y ? (10%) [Hint: Express in real components.]
 (b) Find the surface current \mathbf{K} on the bottom of the inner wall (the yz plane)? (10%) [Hint: \mathbf{K} is a vector.]



5. Birefringence: the wave plate

Linearly polarized light entering a wave plate can be resolved into two waves, parallel and perpendicular to the optical axis of the wave plate. In the plate, assume that the parallel wave (k_y) propagates slightly slower than the perpendicular one (k_x).

$$\text{Near side: } f_0 = A_0 \cos(k_x z_0 - \omega t) \hat{\mathbf{x}} + A_0 \cos(k_y z_0 - \omega t) \hat{\mathbf{y}}$$

$$\text{Far side: } f_d = A_0 \cos(k_x(z_0 + d) - \omega t) \hat{\mathbf{x}} + A_0 \cos(k_y(z_0 + d) - \omega t) \hat{\mathbf{y}}$$

- (a) At the far side of the plate, can we change the polarization of the resulting combination orthogonal to its entrance state? At what condition? (10%)
 (b) Is it possible to form a right or left hand circular polarization? At what condition? (10%)

