1. (a) Derive the electrostatic potential U(r) at any point r inside a sphere of uniform charge density $\rho = e/(\frac{4}{3}\pi R^3)$.

(b) Calculate the electrostatic interaction energy of two protons in the model in which they are taken to be spread uniformly through the same spherical nucleus of radius R.

(c) Calculate the total Coulomb interaction energy (in MeV) of $^{27}_{13}A\ell$. (20 points)

2. A thin dielectric disk of dielectric constant ϵ is placed in an initially uniform field **E**, the basis of the disk being normal to E (Fig.1). Neglecting edge effects, find the final field outside and inside the disk. (15 points)

3. Copper has a conductivity $\sigma = 5.8 \times 10^7$ mhos/meter, and $\mu = 1.26 \times 10^{-6}$ Henry/meter. If a plane wave at a frequency of 200 Hz is normally incident on copper, find the depth of penetration of this wave. (15 points)

4. A thin flat conducting disk of thickness h, diameter D, and resistivity ρ is placed in a uniform alternating magnetic field $B = B_o \sin\omega t$ parallel to the axis of the disk. Find the induced current density as a function of distance from the axis of the disk. What is the direction of this current? (20 points)

5. An infinitely long uncharged circular cylindrical conductor, of radius a, is rotated slowly at a constant angular velocity ω about its axis in a uniform magnetic field $B = B_o \hat{z}$, (Fig. 2)

(a) What are the conditions for equilibrium for the charges in the conductor?

(b) Find the electric field and potential inside the conductor, if the axis is grounded. (V(0) = 0)

(c) Calculate the surface and volume charge per unit length of the conductor. (20 points)

6. Derive the expression for the force **F** on an electric dipole with moment **p** in an **E** field in which $E_x = 0$, $p_x = 0$, and **p** is a constant (10 points)

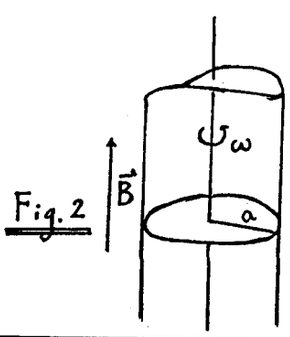

Fig. 2

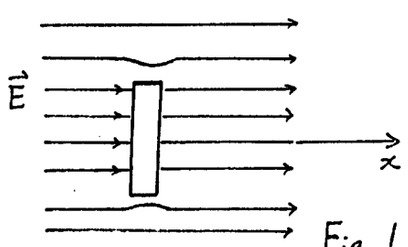

Fig. 1