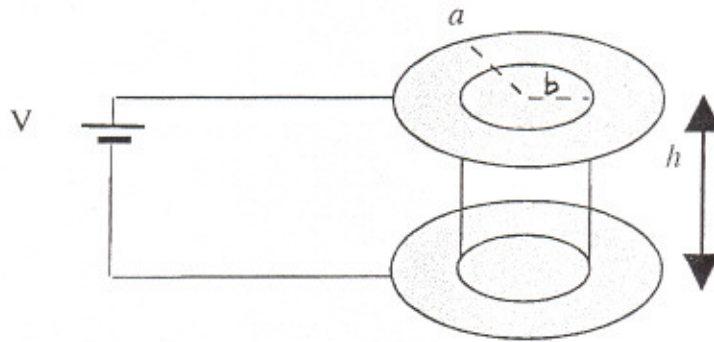


**Candidacy Exam Fall, 2002**  
**Electricity and Magnetism**

**Problem 1:** Consider a sphere of radius  $R$  centered at the origin. Suppose a point charge  $q$  is put at the origin and that this is the only charge inside or outside the sphere. Furthermore, the potential  $\Phi$  at the surface of the sphere is maintained such that  $\Phi = V_0 \cos\theta$ . What is the potential, both, inside and outside the sphere? (30)

**Problem 2:** Two perfectly conducting copper disks of radius  $a$  are separated by a distance  $h$  ( $h \ll a$ ). A solid cylinder of radius  $b$ , length  $h$ , and volume resistivity  $\rho$  fills the center portion of the gap between the disks. The disks are connected to a battery to produce a potential difference of  $V$  volts.



(a) Calculate the electric field everywhere between the plates disregarding any leakage fields as a function of radial distance after the battery has been connected for a long time. (15)

(b) Calculate the magnetic field everywhere in the gap as a function of distance  $r$  from the axis of the disks. (15)

(c) Calculate the Poynting's vector in the space between the plates. Explain qualitatively why the vector has this specific direction at  $r = a$  and  $r = b$ . (15)

**Problem 3:** Consider a rectangular loop of wire, of width  $a$  and length  $b$ , rotating with an angular speed of  $\omega$  about an axis parallel to the side  $b$ . It is placed in a uniform, time dependent field  $B = B_0 \sin(\omega t)$  perpendicular to the loop at  $t = 0$ . Find the *emf* induced in the loop and show that it alternates with a frequency of  $2\omega$ . (25)