1. [20 %] An uncharged metal sphere of radius R is placed in an otherwise uniform electric field $\vec{\mathbf{E}} = E_0\vec{k}$. The field will push positive change to the "northern" surface of the sphere, leaving a negative change on the "southern" surface.
   (a) Find the potential in the region outside the sphere. (10 %)
   (b) Find the induced charge density on the surface. (10 %)

2. [30 %] A spherical shell of radius R, carrying a uniform surface charge σ, is set spinning at angular velocity ω.
   (a) Find the vector potential it produces inside and outside the rotating shell. (10 %)
   (b) What is the magnetic dipole moment of the rotating shell? (10 %)
   (c) Find the electric field inside and outside the sphere if the angular velocity $\omega(t)$ changes slowly with time. (10 %)

3. [10 %] (a) State the Biot-Savart law which gives the magnetic field $\vec{\mathbf{B}}$ at a distance r from a current element. Hence obtain an expression for the magnetic field $\vec{\mathbf{B}}_Q$ due to a point change Q moving with constant velocity $\vec{\mathbf{v}}$ (assuming non-relativistic). (5 %)
   (b) Point charges Q and Q' are constrained to move along the $x-$ and $y-$axes, respectively, with the same uniform speed v. At $t = 0$ both charges are at the origin. At time t calculate the Lorentz force $\vec{\mathbf{F}}$ on Q' due to the magnetic field of Q. (5 %)

4. [10 %] A long coaxial cable carries current I (the current flows down the surface of the inner cylinder, radius a, and back along the outside cylinder, radius b) as shown in Fig. 1. Find the energy stored in a section of length l.

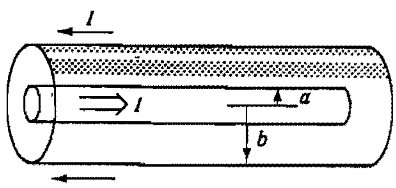

Fig. 1

5. [20 %] Find the charge and current distributions that would give rise to the potentials $V = 0$,

$$\vec{\mathbf{A}} = \begin{cases} \frac{\mu_0\alpha}{4c}(ct - |x|)^2\vec{k}, & |x| < ct \\ 0, & |x| > ct \end{cases}$$

(here α is some constant, and c is shorthand for $1/\sqrt{\epsilon_0\mu_0}$).

6. [10 %] Find the Lienard-Wiechert potential of a point charge moving with constant velocity $\vec{\mathbf{v}}$.