(25%)

1. A metal sphere of radius R, carrying charge q, is surrounding by a thick concentric metal shell (inner radius a, outer radius b). The shell carries no net charge.
   (i). Find the surface charge density at R, at a, and at b.
   (ii). Find the electric field at r<R and r>b.
   (iii). Find the potential at the center, using infinity as a reference point.
   (iv). Now the outer surface is touched to a grounding wire, which lowers its potential to zero. How do your answers to (i) – (iii) change?

(15%)

2. A point charge Q exists at a distance d above an infinite conducting plane which has a nonzero potential V.
   (i). Determine the electric potential everywhere.
   (ii). Find the surface charge density on the plane.

(20%)

3. Consider a sphere of radius R is rotating about one of its diameters with angular frequency ω.
   (i). If it has uniform volume charge distribution ρ, determine the magnetic dipole moment.
   (ii). Find the magnetic field at distance far from the sphere.

(25%)

4. Two long coaxial solenoids each carry current I but in apposite directions. The inner solenoid (radius a) has n turns per unit length, and outer one (radius b) has m turns. Find B and H in each of the three regions: (i) inside the inner solenoid, (ii) between them, and (iii) outside both. Evaluate (iv) the mutual inductance and (v) the energy of the system.

(15%)

5. Assume an electromagnetic plane wave has the electric field,

$$\vec{E} = E_1\hat{x}\cos(kz-\omega t) + E_2\hat{y}\sin(kz-\omega t)$$

   where $k=\omega/c$, c is the speed of light and E_1, E_2 are real.
   (i). Determine the polarization of the wave and plot the trace of the tip of $\vec{E}$ in the plane z=0.
   (ii). What is the magnetic field of the wave?
   (iii). Calculate the energy density of the wave.