(1) A spherical charge distribution is given by

$$\rho = \rho_0\left(1-\frac{r^2}{a^2}\right), \qquad (r \le a)$$
$$\rho = 0, \qquad (r > a)$$

(a) Calculate the total charge $Q=?$ (5%)
(b) Find the electric field intensity $\vec{E}$ and the potential $V$ outside the charge distribution. (5%)
(c) Find $\vec{E}$ and $V$ inside. (5%)
(d) Where is the maximum value of $\vec{E}$ ? (5%)

(2) A long wire of radius $a$ carries a current $I$ and is surrounded by a long hollow iron cylinder. The inner radius of the cylinder is $b$ and the outer radius $c$.
(a) Compute the flux of $\vec{B}$ inside a section of the cylinder $l$ meters long. (5%)
(b) Find the equivalent current density on the inner and outer iron surfaces, and find the direction of the equivalent currents relative to the current in the wire. (5%)
(c) Find the equivalent current density inside the iron. (5%)
(d) Find $\vec{B}$ at the distances $r > c$ from the wire. How will this value be affected if the iron cylinder were removed ? (5%)

(3) Show that both the normal and tangential components of the vector potential $\vec{A}$ are continuous across the interface between two media if the currents are constant. (10%)

(4) In general, the electric field and the magnetic field are discontinuous at a boundary between two different media and at a surface which carries charge density $\sigma$ or current density $\vec{K}$.
(a) Write down the integral form of Maxwell equations. (10%)
(b) Deduce the discontinuities of the fields . (15%)

(5) For a monochromatic plane wave in free space has the amplitude of the electric field $E_0$, angular frequency $\omega$, and phase angle zero. If the electromagnetic wave is traveling in the negative $y$-direction and polarized in the $x$-direction,
(a) Write down the electric and magnetic fields. (10%)
(b) Calculate the energy density stored in the wave. (5%)
(c) Calculate the energy flux density transported by the electromagnetic field. (5%)
(d) Calculate the momentum density stored in the wave. (5%)