Answer all five questions, 20 points each

1. A simple capacitor is a device formed by two insulated conductors adjacent to each other. If equal and opposite charges are placed on the conductors, there will be a certain difference of potential between them. The ratio of the magnitude of the charge on one conductor to the magnitude of the potential difference is called the capacitance. Calculate the capacitance, C, of two concentric spherical shells of radii a and b. The space between them is filled with a medium whose permittivity is given by

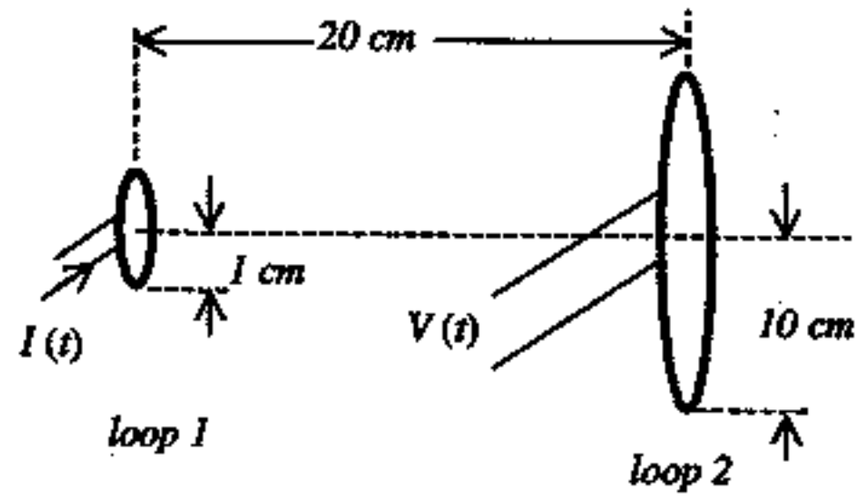
$$\varepsilon(r) = \begin{cases} \varepsilon_1 = \text{constant}, & a \le r < c, \\ \varepsilon_2 = \text{constant}, & c \le r \le b, \end{cases}$$

where $a < c < b$. Find the distribution of bound charges, σ_b, and the total bound charge in the dielectric in terms of the charge Q on the inner electrode of the capacitor.

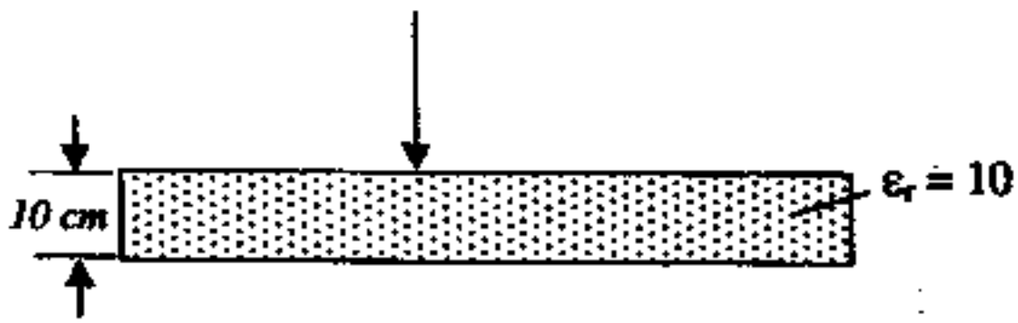
2. Consider a metallic rectangular box with sides a and b and height c. The side walls and the bottom surface are grounded. The top surface is isolated and kept at a constant potential V_0. Determine the potential distribution inside the box.

3. Consider two circular loops of radius *1 cm* and 10 *cm* and number of turns *10* and *2* turns, respectively. The two loops are placed in parallel with a distance of *20 cm*, as shown in Fig. 2. The loop 1 is driven by a time varying (sinusoidal) current with amplitude *2.0 A* and frequency *50 Hz*. Determine the voltage induced on the terminal of loop 2. (You may make reasonable approximations.) (20 %)

Fig. 2



4. A plane wave incidents normally on a planar dielectric slab with a dielectric constant *10* and a thickness *10 cm*. Find the lowest frequency of the wave at which the reflected wave vanishes. (20 %)



5. Starting from the Maxwell's equations, derive the equation of the Poynting theorem and explain in details the physical meaning of each term in the equation. (20 %)