1. Figure 1 shows diagrammatically two different processes, in each of which a lock of dielectric is inserted between the plates of a charged capacitor. Prove that $F = -\nabla U|_{q=const.}$ and $F = \nabla U|_{V=const.}$ in this two differnt processes. Where U is the total electrostatic energy. (15 onts)

2. Estimate the skin depth and wave velocity in copper (conductvity $= 6 \times 10^7$ mho/m) at a frequency of 1 gigahertz (10^9 Hz). (10 points)

3. A magnetic circuit comprises a permeable " yoke" (length ℓ_1, area A_1, permeability μ), an air gap (ℓ_2, A_2), and a permanent bar magnet (ℓ_3, A_3). Calculate the flux in terms of the value of H in the bar magnet. (15 points)

4. Find the magnetic dipole moment of the spinning spherical shell. Note that you can express it in terms of q, the total charge of the shell; R, the radius of the shell, and ω, the angular velocity of the spherical shell. (15 points)

5. Two dipoles of moments p_1 and p_2 are placed at a distance r from each other. If the moments of the dipoles are directed along the line joining them, find the force exerted by one dipole upon the other. (15 points)

6. Find the explict form of E_z for a TM wave, and the explicit form of H_z for a TE wave. (15 points)

7. A small sphere of radius a and permeability μ is placed at a distance $x >> a$ from a small magnet of dipole moment m. The direction of m is along the line joining the magnet with the sphere. Find the force exerted by the magnet on the sphere. (15 points)
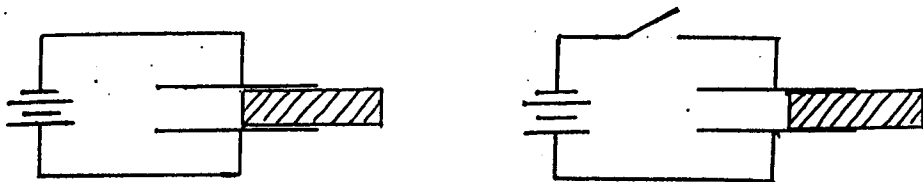

Fig. 1