***** Show your derivations in details !!***

***Make clear all your assumptions/approximations!!***

1. A cubical box consists of four metal sides which are welded together and grounded (see Fig. 1). The **top** and **bottom** are made of separate sheets of metal, insulated from the rest, and held at a constant potential $V_0$ by a battery. Find the potential inside the box. The sides are all of **length** $a$. (20 %)

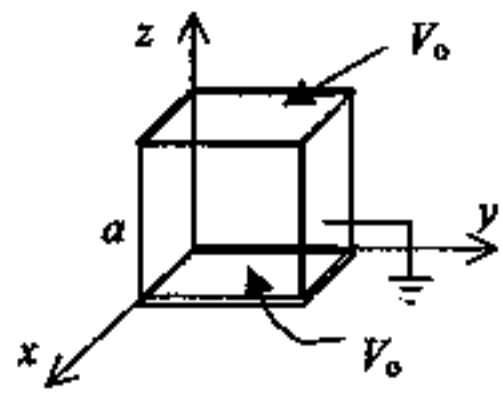


Fig. 1

2. (a) Write down the Lorentz force Law. (20 %)
   (b) Show that magnetic forces do no work.
   (c) Describe the trajectory of a charged particle with velocity **v** in a uniform magnetic field **B**.
   (d) Describe the trajectory of a charge particle initially at rest (**v** = 0) in a region having both uniform electric field **E** and magnetic field **B**, assuming $\mathbf{E} \perp \mathbf{B}$.

3. A current transformer can be used to measure currents in a wire, as shown in Fig. 2. Assuming the infinite long wire has a diameter of *1 cm* and coincides with the principle axis of symmetry of a *20* turn coil wrapped uniformly around a rectangular, toroidal-shaped iron core of inner and outer radii $a = 5\ cm$ and $b = 10\ cm$, thickness $t = 5\ cm$, and relative permeability $\mu_r = 1000$. The current, which is uniformly distributed in the wire, varies with time sinusoidally at frequency *1 kHz* and amplitude *1 Ampere* peak to peak. Find the induced voltage $V_{ind}$ between the terminals of the coil. (20 %)

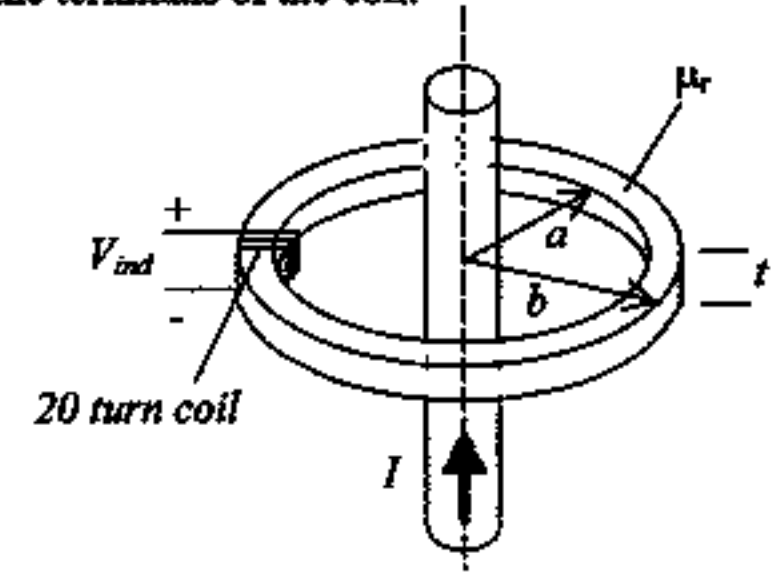


Fig. 2

4. (a) Explain the *physical meaning* of (20 %)
   (i) phase velocity, and (ii) group velocity
   (b)An oscillating electric dipole $\mathbf{P}(t) = P_o \cos(\omega t)\hat{y}$ is located at the origin, as shown in Fig. 3. Determine the directions of the electric field, magnetic field and Poynting vector at points A, B and C, respectively. Assuming the distances from A, B and C to the origin are the same and much larger than $c/\omega$, where c is the speed of light.

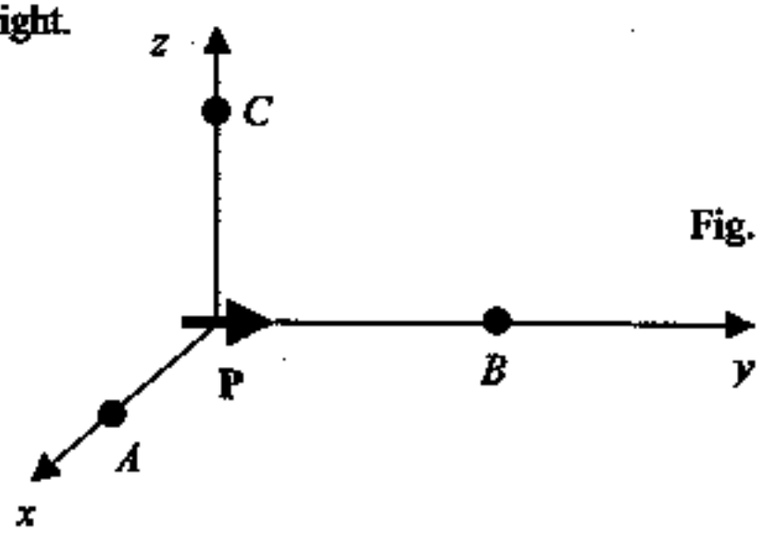


Fig. 3

5. A capacitor formed by two large parallel conductor is partly filled with a dielectric of dielectric constant $\varepsilon_r = 10$, as shown in Fig. 4. Find the *force per unit area* on the top conductor (grounded) if a DC voltage of *200 V* is applied on the bottom plate. (20 %)

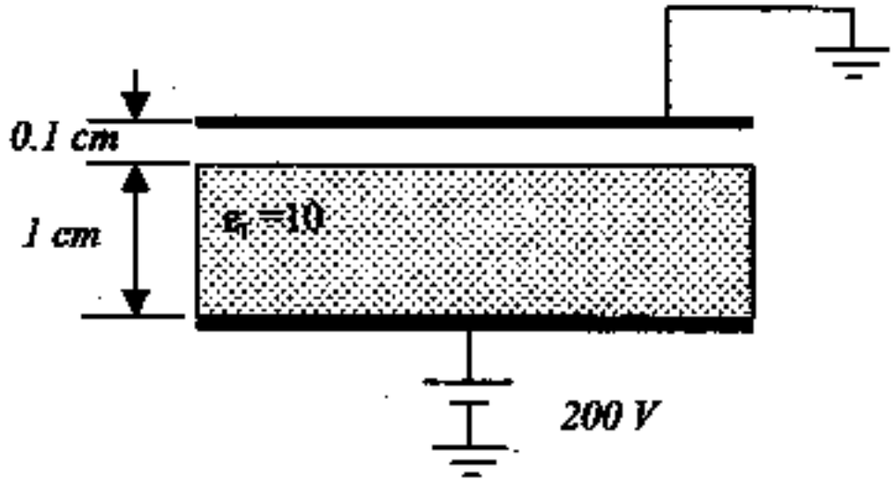


Fig. 4