EASTERN UNIVERSITY, SRI LANKA

FIRST EXAMINATION IN SCIENCE - 2002/2003

(MARCH/APRIL 2004)

REPEAT

PH103 & PH104

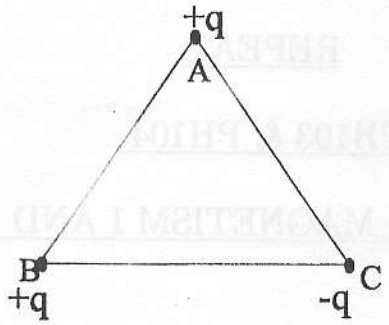
ELECTRICITY AND MAGNETISM I AND AC THEORY

Time: 02 hour.

Answer Four questions only selecting minimum Two from each section.

SECTION A

1. State Coulomb's law in Electrostatics.
   Three charges are arranged in an equilateral triangle as shown in the figure.



   (i) Find the magnitude and direction of the force at point A.
   (ii) Find the magnitude and direction of the force at point C.
   (iii) If the point A is replaced by charge $+3q$, what is the magnitude of the force at point A?.

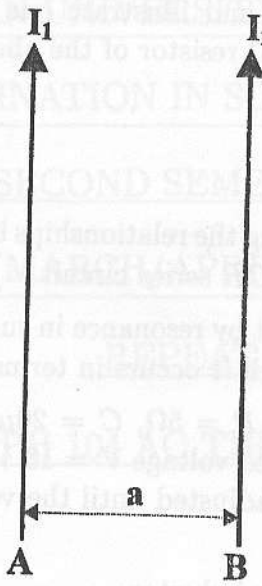
2. State Gauss's theorem in electrostatics.
   The volume charge density of a cylinder of radius a at a distance r from its axis is

$$\rho = \rho_0 \left(1 + \frac{r^2}{a^2}\right)$$

   (i) Show that the charge contained in the cylinder per unit length is $\frac{3}{2}\pi\rho_0 a^2$.
   (ii) Find the electric field strength when $r < a$ and $r > a$.

3. State Biot-Savart Law and derive an expression for the B-field produced by an infinitely long current carrying conductor at a distance a. Consider two long straight current carrying conductors carrying currents I_1, I_2 in same directions as shown in the figure.

   (i) Find the magnitude and the direction of the magnetic field at the conductor B due to conductor A.

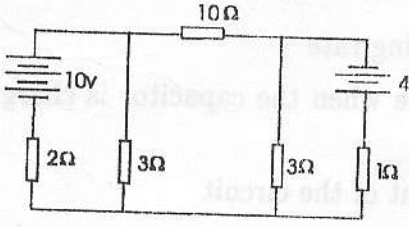


(ii) Find the magnitude and the direction of the magnetic field at the conductor A due to conductor B.

(iii) Find the magnitude and the direction of the force on conductor B due to conductor A.

(iv) If $I_1 = 10A, I_2 = 8A$ and $a = 4cm$ calculate the magnetic force on conductor B due to conductor A. Assume that $\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$.

SECTION B



4. State Thevenin's theorem and illustrate one of it with an example. Find the current in the 10Ω resistor of the above circuit using

   (i) Thevenin's theorem

   (ii) Norton's theorem

5. (a) Sketch a graph showing the relationships between current, impedance and frequency in a LCR series circuit.

   (b) Explain what is meant by resonance in such a circuit and calculate the frequency at which it occurs in terms of L and C.

   (c) A series circuit with $R = 5\Omega$, $C = 20\mu F$ and a variable inductance L has an applied voltage $V = 10\ Volts$ with a frequency of $1000\ radsec^{-1}$. L is adjusted until the voltage across the resistor is a minimum. Find

      (i) inductance of the inductor

      (ii) the current through the circuit

      (iii) the voltage across the capacitor

      (iv) the voltage across the resistor

6. A series circuit consists of a capacitor C, resister R and a battery of e.m.f E. The capacitor is initially uncharged. Show that after a time t the capacitor carries a charge Q given by

$$Q = Q_0 \left[1 - exp\left(-\frac{t}{CR}\right)\right]$$

   where Q_0 is the final charge on the capacitor.

   A $20\mu F$ capacitor is connected in series with a $1M\Omega$ resistor and a $100V$ battery. Calculate

   (i) the initial charging rate

   (ii) the charging rate when the capacitor is charged to one-fourth of the final charge

   (ii) the time constant of the circuit