NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1105 – ELECTRICITY AND MAGNETISM

BSC HONOURS PART I: DECEMBER 2004 *DURATION: 3 HOURS*

ANSWER <u>ALL</u> PARTS OF QUESTION 1-IN SECTION A AND ANY <u>THREE</u> QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

Gravitational constant G	$= 6.67 \times 10^{-11}$ Nm^2 kg^{-2}
Permittivity of free space ε_0	$= 8.85 \times 10^{-12}$ Fm^{-1}
Permeability of free space μ_0	$= 1.26 \times 10^{-6}$ Hm^{-1}
Electron mass m_e	$= 9.11 \times 10^{-31}$ kg
Proton mass m_p	$= 1.66 \times 10^{-27}$ kg
Charge on an electron e	$= 1.60 \times 10^{-19}$ C

SECTION A

1. (a) What are the fundamental characteristics of an electric charge? [4]

(b) Calculate the force on the charge q_3 due to the other two charges located as shown in Figure 1 below. Take magnitudes of charges as $q_1 = -3$ μC, $q_2 = +2.3$ μC and $q_3 = +1.1$ μC. [4]

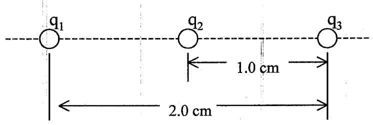

Figure 1

(c) Explain briefly how static electricity can be used in dust extraction. [4]

(d) Find the equivalent resistance between points 'a' and 'b'. If the potential difference between 'a' and 'b' is 15 V, find the current in each resistor. [4]

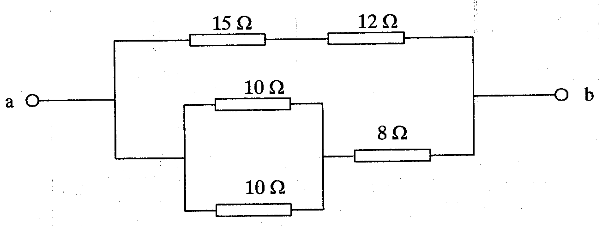

Figure 2

(e) A galvanometer of internal resistance 20 Ω reads full scale deflection when 5.0 mA passes through it. Design a voltmeter that will read 10 V at full scale deflection. [4]

(f) Draw the lines of force of an electric dipole and that of a magnetic dipole. State the similarities and differences, if any. [4]

(g) Define flux of a magnetic field. Illustrate it with the help of a diagram. [3]

(h) An electric field of 1.5 kV and and a magnetic field of 0.4 T act on a moving electron to produce no force.
(i) Calculate the minimum electron speed
(ii) Draw the vectors E, B, and V. [5]

(i) Why would power distribution less effective without alternating emfs? [3]

(j) An LC circuit oscillates at 10.4 kHz.
(i) If the capacitance is 340 F, what is the inductance?
(ii) If the maximum current is 7.2 mA, what is the total energy in the circuit?
(iii) Calculate the maximum charge on the capacitor? [5]

SECTION B

2 (a) (i) State Gauss's law and explain the physical meaning of all quantities involved. [4]

(ii) Use Gauss's law to show that

$$E = 2k\lambda r / a^2$$

for a non conducting wire of linear charge density λ, where $r<a$ and E is the electric field, r and a are variable and are fixed radii of a concentric sphere respectively. [6]

(iii) Explain why the electric field is zero at all points inside a hollow sphere. [4]
(iv) What do you think will happen to a positive test charge placed inside a positively charged hollow sphere? [2]

(b) What are (i) the charge and (ii) the charge density on the surface of a conducting sphere of radius 0.15 m whose potential is 200 V with potential = 0 at infinity. [4]

3 (a) State Kirchhoff's rules. [2]

Find the current in each part of the circuit shown in Figure 3 below. [9]

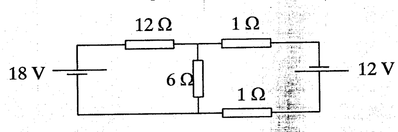

Figure 3

(b) A 1.0 μF capacitor with an initial stored energy of 0.50 J is discharged through a 1.0 MΩ resistor.

(i) What is the initial charge on the capacitor. [3]

(ii) What is the current through the resistor when the discharge starts. [3]

(iii) Determine V_c, the voltage across the capacitor and V_R, the voltage across the resistor as a function of time. [3]

4 (a) State

(i) Ampere's law

(ii) Faraday's law and

(iii) Lenz's law. [6]

(b) (b) Describe the motion of a positive charge if it is:

(i) released into a uniform magnetic field of intensity B at an angle θ to the field.

(ii) released into the same field with a velocity directly perpendicular to the field. [4]

(c) Show that the magnetic field inside a very long solenoid of length l is given by $B = \mu_o in$ where symbols have there usual meaning. [4]

(d) A long solenoid has 200 turns/cm and carries a currentof 1.5 A, and its diameter is 30 cm. A 100 turn close packed coil of diameter 2.0 cm is placed at its centre. The coil is placed so that B at the centre of the solenoid is parallel to its axis. The current in the solenoid is reduced to zero and then raised to 1.5 A in the other directionat a steady rate over a oeriod of 0.05 s. What induced emf appears in the coil while the current is being changed? [6]

5 (a) Distinguish between potential and potential difference. [4]

(b) What is an equi-potential surface? [2]

(b) Three positive 2 μC point charges are at the corners of a square of side 3 m.

(i) What is the potential V at the fourth unoccupied corner of the square. [3]

(ii) How much work is needed to bring up a fourth positive charge of 2 μC and place it at the fourth corner of the square? [3]

(c) Find the potential on the axis of a disk of uniform surface charge density σ. [8]

6 (a) Distinguish between reactance and impedance.
Illustrate your answer with relevant expressions. [5]

(b) In a certain LCR circuit $X_c = 16\ \Omega$, $X_L = 4\ \Omega$ at some frequency ω. The resonance frequency $\omega_o = 10^{4}$ rad/s.
(i) Find L and C. [4]

If R = 5Ω and $\varepsilon_{max} = 26$ V, find
(ii) the Q value, [3]
(iii) the maximum current. [3]

(c) Compute by direct integration the area under the curve $\sin^2\omega t$ from t = 0 to t = T = $2\pi/\omega$ and show that it is equal to $\frac{1}{2}T$. [5]

- END OF EXAMINATION -