SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

DEPAFRTMENT OF PHYSICS

SPH 202 ELECTRICITY AND MAGNETISM II

EXAM QUESTIONS

1ST SEMESTER (MAY/AUGUST, 2013)

SECTION A

Question 1 of this section is **COMPULSORY (30 MARKS)**

1. a) (i) What are the forces in play on a circulating charge in a magnetic field. **(2 marks)**
(ii) Show that the period, T for the charge in (i) is given by

$$T = 2\pi m/Bq$$

Where m = mass of circulating charge
B = magnetic field intensity and q =charge **(5 marks)**

b) (i) Define magnetism. **(1 mark)**
(ii) The magnetic properties of materials are, in large part, determined by the nature and magnitude of the atomic magnetic moments. Cite any four forms of magnetic behavior that can be observed. **(2 marks)**

c) (i) In the practical LC circuit, oscillations eventually come to stop. Why? **(2 marks)**
(ii) Figure one shows an electrical circuit.

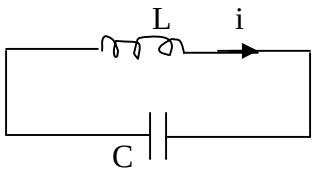


Fig.1

Derive the equation that describes the oscillations in the circuit. **(5 marks)**

d) (i) Define an **electric flux**. **(2 marks)**
(ii) A cylinder of radius R, immersed in a uniform electric field **E**, is shown in figure 2. The cylinder axis is parallel to the field.

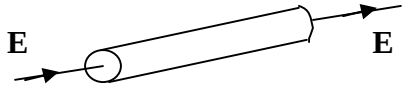


Fig. 2

Calculate flux Φ_E for this closed surface. **(5 marks)**

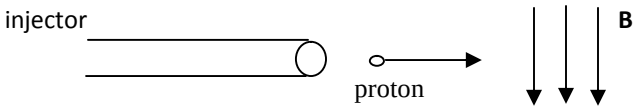
e) (i) State Gauss' law in words **(2 marks)**
(ii) What is the importance of the above law in the study of electromagnetism? **(1 mark)**
(iii) Use Gauss' law to determine the electric field intensity **E** at a distance r from a point charge Q in empty space. **(3 marks)**

SECTION B : Answer **ONLY TWO** questions from this section. Each Question is **20 marks**.

2. a) In a hydrogen atom, an electron cycles the nucleus 6.6×10^{15} times per second at a radius of 0.53×10^{-10} m. Find the magnetic moment of the hydrogen electron resulting from its orbital motion. (Let electron charge be 1.67×10^{-19}C). **(4 marks)**

b) The velocity of a proton is 1.2×10^{4} m/s and is perpendicular to the magnetic field **B** = 0.6 T as shown in figure 3. Mass of the proton is 1.66×10^{-27} kg.

Fig. 3



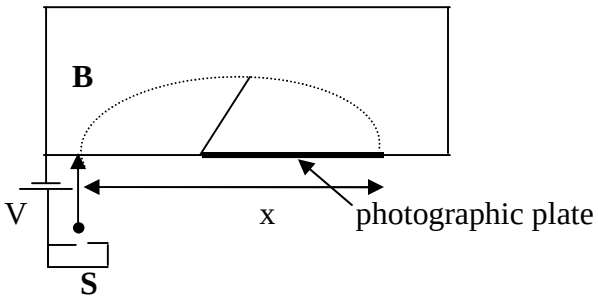
(i) Calculate the magnitude of the force F acting on the proton. **(4 marks)**
(ii) Draw the trajectory of the proton showing the direction of the force **F** and velocity **v** when **B** points into the page. **(3 marks)**

c) (i) Explain how an oscillating electric field inside a microwave oven heats food. **(5 marks)**
(ii) Explain why some microwave ovens would heat food unevenly. **(4 marks)**

3. a) (i) The coil of a galvanometer is 2.1 cm high and 1.2 cm wide. It has 250 turns and is mounted so that it can rotate about an axis in a uniform radial magnetic field with **B** = 0.23T. For any orientation of the coil, the net magnetic field through the coil is perpendicular to the normal vector of the coil. If a current 100 μA produces an angular deflection of 28º, what must be the torsional constant K of the spring? **(4marks)**
(ii) Calculate the magnetic dipole moment **μ** of the coil. **(3 marks)**
(iii) The magnetic dipole moment of the galvanometer coil is lined up with an external field whose strength id 0.85T. How much work would be required to turn the coil to the end. **(3marks)**

b) Figure 4 shows the essentials of a mass spectrometer.

Fig.4



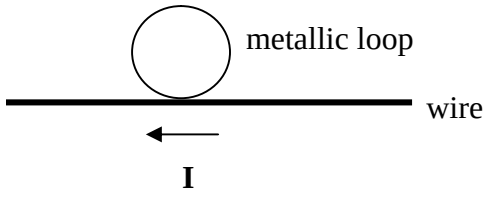
An ion of mass m and charge q is produced by source S. The stationary ion is accelerated by the electric field due to potential difference V. The ion leaves S and enters a *separator chamber* in which a uniform magnetic field B(out of the page) is perpendicular to the path of the ion. The magnetic field causes the ion to move in a semicircle of radius r, striking a photographic plate at a distance x from the entry point of the slit. Suppose that a certain trial B = 80 mT and V = 1000V and ions of charge $q = +1.6022 \times 10^{-19}$ C strike a plate at x = 1.6254m. What is the mass of the individual ions? **(10 marks)**

4. a) State Faraday's law of induction. **(2 marks)**

b) (i) A long solenoid has 200 turns/cm and carries a current of 1.5 A. Its diameter is 3.0 cm. At its centre is placed 100-turn closed-packed coil of diameter 2.0cm. The coil is arranged 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 direction at a steady rate over a period 0.05s. Calculate the value of the induced emf that appears in the coil while the current is being changed.
($\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}) **(10 marks)**
(ii) A long solenoid length l = 0.5m and X-sectional area of $10cm^2$ is closely wound with 1000 turns (N_1) of wire. A small coil of 10 turns (N_2) surrounds it at its centre. Calculate the mutual inductance (M) of the system. **(4 marks)**

c) (i) The electric current in a wire shown in figure 5, is flowing as shown and is decreasing. What is the direction of the induced current in he metallic loop kept above the wire? **(1mark)**

Fig.5



(ii) Name and state the law which helps in finding the direction of the induced current in (i) above. **(3 marks)**

5. a) (i) What is the source of magnetism in magnetic solids? **(1 mark)**
(ii) In which materials is the entity in (i) found? **(2 marks)**
(iii) Name and define the parameter which characterizes the materials in (ii). **(3 marks)**

b) Differentiate between diamagnetism, paramagnetism and ferromagnetism. **(7 marks)**

c) (i) Give three examples of magnetic dipoles. **(3 marks)**
(ii) Magnitude of magnetic dipole **μ** can be measured by placing the dipole in an external magnetic field B, and measuring the torque **τ .** Give the relation between these parameters. **(1 mark)**
(iii) A paramagnetic gas whose atoms have a magnetic dipole moment of 10^{-23} Am^2 is placed in an external magnetic field of $1W/m^2$ at room temperature. Calculate the magnetic energy U_B involved. **(3 marks)**