JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION

2ND YEAR 2ND SEMESTER 2018/2019

MAIN

COURSE CODE: SPH 202

COURSE TITLE: ELECTRICITY AND MAGNETISM II

EXAM VENUE: **STREAM: (B.Ed Sc)**

DATE: **EXAM SESSION:**

TIME: 2:00 HRS

INSTRUCTIONS:

1. **Attempt question 1 (compulsory) and ANY other two questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

Useful constants

$1/4\pi\epsilon_0 = 9.0 \times 10^9$ N m^2 C^{-2}
mass of proton $= 1.67 \times 10^{-27}$ kg
electron charge $= -1.6 \times 10^{-19}$ C
permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}

Question 1

(a) State Gauss' law

(1 Marks)

(b) An infinitely long conducting cylinder of radius 12 cm has a linear charge density of 3 nC/m. Find the electric field strength 10 cm from the surface.

(3 Marks)

(c) A rectangular loop of dimensions 12 cm $\times$ 7 cm is placed in a 0.2 T magnetic field. The normal to the plane of the loop is at an angle of 40° to the magnetic field. If a current of 3 A flows in the loop,

(i) Find the magnetic moment of the loop.

(3 Marks)

(ii) Hence find the magnitude of the torque.

(3 Marks)

(d) A capacitor $C = 10\mu$F is connected across an inductor $L = 8$ mH. What is the frequency of oscillation?

(2 Marks)

(e) (i) What is an electric dipole?

(ii) A dipole with dipole moment 4.5×10^{-30} C m is placed in a uniform electric field $E = 9 \times 10^4$ N/C at 50° to the field. Determine the magnitude of the torque exerted by the field.

(1,3 Marks)

(f) Explain the principle of operation of the tuning circuit of an AM radio.

(4 Marks)

(g) A coil with 20 turns of wire is wrapped on a frame with a square cross-section 1.9 cm each side. Each turn has the same area, equal to that of the frame, and the total resistance of the coil is 0.25 Ω. An applied uniform magnetic field is perpendicular to the plane of the coil.

(i) If the field changes uniformly from 0.00 T to 0.50 T in 0.80 s, find the induced emf in the coil while the field is changing.

(6 Marks)

(ii) Find the magnitude of the induced current in the coil while the field is changing.

(2 Marks)

(h) Explain the variation of current with time in an ordinary circuit when the switch is closed.

(3 Marks)

Question 2

(a) Show that the current in an LR circuit at $t = \infty$ is

$$I = I_0(1 - e^{-t/\tau})$$

where the symbols have their usual meanings.

(6 Marks)

(b) The current in an LR circuit builds up to one third of its final value in 5.00 s. Find the time constant.

(4 Marks)

(c) In the tuning circuit of an AM radio, the inductance is 5 mH. Over what range must the capacitance vary for the circuit to detect AM frequencies from 550 kHz to 1600 kHz?

(6 Marks)

(d) Discuss Lenz's law in relation to the principle of conservation of energy.

(4 Marks)

Question 3

(a) Distinguish between a magnetic flux and a magnetic field.

(2 Marks)

(b) (i) Explain what you understand by the magnetic dipole of a coil.

(2 Marks)

(ii) A circular coil of 160 turns has a radius of 1.90 cm. Calculate the current that results in a magnetic dipole moment of magnitude 2.30 A m^2.

(3 Marks)

(iii) Find the maximum magnitude of the torque that the coil can experience in a uniform 35.0 mT magnetic field while carrying the current in (b)(ii) above.

(3 Marks)

(c) Show that the potential energy of an electric dipole in an external magnetic field is given by

$$U = -\vec{p} \cdot \vec{E}$$

(7 Marks)

Question 4

(a) (i) Give two qualities of a good dielectric.

(ii) Explain why the capacitance of a capacitor cannot be increased indefinitely by reducing the separation of the plates.

(2,1 Marks)

(b) A parallel plate capacitor has plates 3.0 cm by 4.0 cm. The plates are separated by an insulating material 1.2 mm thick, of dielectric constant 4.9. Find:

(i) The capacitance of the capacitor.

(3 Marks)

(ii) The maximum charge that can be placed on the capacitor if the dielectric strength of the material is 24×10^6 V/m.

(4 Marks)

(iii) The surface charge density on the plates in (b)(ii) above in $\mathrm{C/m^2}$.

(2 Marks)

(c) A parallel plate capacitor with a plate separation d has a capacitance C_0 in the absence of a dielectric. A slab of dielectric material of dielectric constant κ and thickness $2d/3$ is then inserted between the plates, parallel to the plates. Find the capacitance of this partially filled capacitor in terms of C_0 and κ.

(8 Marks)

Question 5

(a) (i) Sketch on a single graph the variation of impedance, capacitive reactance and inductive reactance with frequency of the a.c. voltage supply in a series LC circuit.

(3 Marks)

(ii) Derive an expression for the resonant frequency f_0 in an LC circuit.

(3 Marks)

(b) A series LCR a.c. circuit has resistance $3.5 \times 10^2\ \Omega$, inductance 0.500 H, capacitance 4.8 μF, frequency 80.0 Hz and maximum voltage 2.5×10^2 V. Find:

(i) the impedance of the circuit.

(4 Marks)

(ii) the maximum current in the circuit

(2 Marks)

(iii) the phase angle.

(2 Marks)

(iv) the maximum voltage across each element.

(3 Marks)

(c) Explain what you understand by diamagnetic, paramagnetic and ferromagnetic materials.

(3 Marks)