JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL PHYSICAL MATHEMATICS AND ACTUARAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 2ND SEMESTER 2020/2021 ACADEMIC YEAR

MAIN

REGULAR

COURSE CODE: SPB 9110

COURSE TITLE: ELECTRICITY AND MAGNETISM I

EXAM VENUE: **STREAM: EDUCATION**

DATE: **EXAM SESSION:**

TIME: 2:00 HRS

Instructions:

1. **Answer question 1 (Compulsory) and ANY other 2 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.**

You may need to use the following constants

- *Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m ($k = 8.99 \times 10^9 Nm^2C^{-2}$)*
- *Mass of an electron, $M_e = 9.11 \times 10^{-31}$ Kg*
- *Mass of a proton, $M_p = 1.67 \times 10^{-27}$ Kg*
- *Electronic charge, $e = 1.6 \times 10^{-19}$ C*
- *Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ Tm/A*
- *$1eV = 1.6 \times 10^{-19}$ J*

SECTION A

QUESTION ONE (30 MARKS)

a) Define Capacitance [2 marks]

b) Derive the Coulomb's law of electrostatics [4 marks]

c) charge $q_1 = 4.0\ \mu C$ is located at the origin, and a charge $q_2 = -2.0\ \mu C$ located at (0.8.0) m.

i. Find the magnitude of force between them [4 marks]

ii. Calculate the potential experienced by q_1 due to q_2 [4 marks]

d) What is the electric field due to an infinitely long wire carrying a linear charge density λ C m^{-1}? [4 marks]

e) Two point charges $q_1 = 3.0 \times 10^{-9}$ C and $q_2 = -3.0 \times 10^{-9}$ C are separated by 2.0mm, forming an electric dipole.

i. Find the electric dipole moment [4 marks]

ii. The charges are in uniform electric field whose direction makes an angle of 24.0° with the line connecting the charges. What is the magnitude of this field if the torque exerted on the dipole has magnitude $6.0 \times 10^{-9} N.m$ [4 marks]

f) An electron in a hydrogen atom orbits the nucleus at a mean distance of 5.29×10^{-11} m. The nucleus (a proton) has a mass of 1.67×10^{-27} kg and the electron has a mass of 9.11×10^{-31} kg. Calculate the electrostatic force between an electron and a proton. [4 marks]

g) A proton travels with a speed of 2×10^6 m/s at an angle of 40.0° with the direction of a magnetic field of 0.500 T. Determine:

i) the magnitude of the magnetic force on the proton [4 marks]

ii) its acceleration? [4 marks]

QUESTION TWO (20 MARKS)

a) A parallel plate capacitor has circular plates of 2.4 cm radius separated by 1.4mm of air. They are connected to a 240V power supply and allowed to charge up before being disconnected.

i. Calculate the capacitance of this capacitor. [4marks]

ii. What charge will appear on the plates? [4marks]

iii. What is the electrical energy stored between the plates? [4marks]

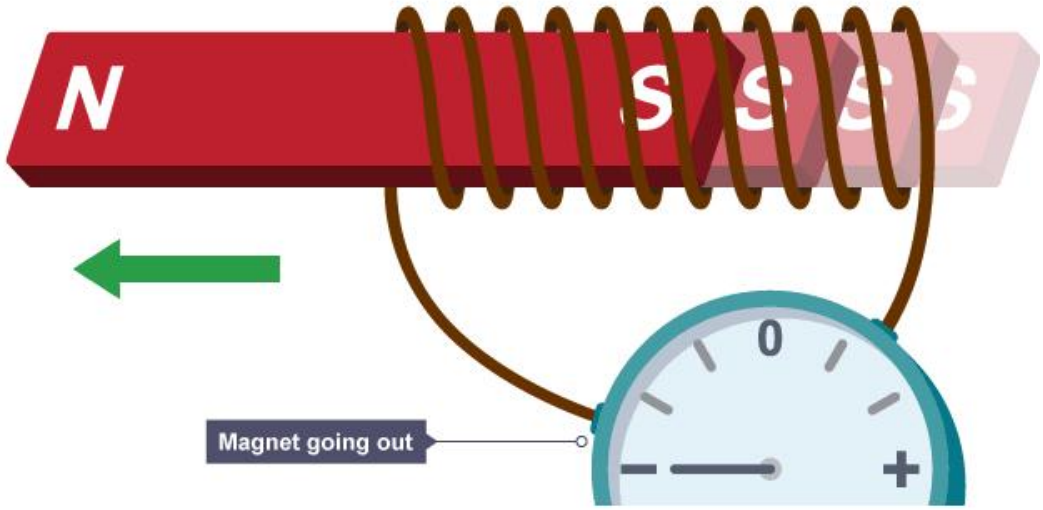
iv. If the plates are pulled apart to a separation of 2.6 mm without affecting the charge distribution, what happens to the electric field between the plates?

[4marks]

b) A coaxial cable connecting a TV to an antenna socket is 6 m long. The inner conductor has an outer radius of 0.5 mm, the outer conductor has an inner radius of 3.5 mm. The space between the conductors is filled with plastic with $\kappa = 4.6$. What is the capacitance of this cable? [4marks]

Question 3 [20 marks]

The following diagram shows a bar magnet moving out of a coil of wire that is connected to a milliammeter. The meter registers a negative induced current.



a. State the **Lenz's Law** [3marks]

b. Describe and give reasons for what you would see on the meter when:

i. the S pole was moved into the coil. [3marks]

ii. the N pole was moved out again but faster. [3marks]

iii. the magnet remained stationary inside the coil. [3marks]

c. A student then decides to move the magnet in and out of the coil continuously.

i. Describe the effect on the meter. [4marks]

ii. Explain this type of electrical current [4marks]

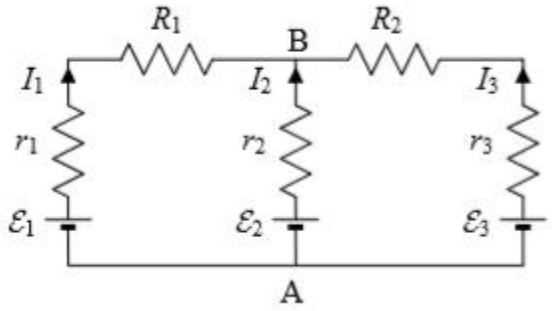
Question 4 [20 marks]

a. Given three resistors of resistances R_1 ,R_2 ,R_3 and R_4, derive an expression for R that:

i. Maximize the equivalent resistance [5marks]

ii. Minimize the equivalent resistance? [5marks]

b. The circuit below consists of 3 different imperfect batteries connected to two equal resistors. Find the currents I_1, I_2 and I_3 leaving the batteries, and the potential difference from A to B, V_{AB}. [10marks]



Take $\mathcal{E}_1 = 6$ V, $r_1 = 1\Omega$, $\mathcal{E}_2 = 10$ V, $r_2 = 2\Omega$, $\mathcal{E}_3 = 12$ V, $r_3 = 3\Omega$ and $R_1 = R_2 = 20\Omega$. [6marks]

Question 5 [20 marks]

a. Define Magnetic flux [2 marks]

b.

i. Discuss any two factors that determines the magnitude of magnetic flux [4 marks]

ii. A circular wire with a 3.6 cm radius is in a constant magnetic filed **B** whose magnitude is 0.84T. Find the magnetic flux through the loop when its normal makes an angle of 50^o with the direction of the magnetic field [5 marks]

c. A bar magnet is moved rapidly towards a 45-loop coil of wire. As the magnet moves, the magnetic flux through the coil increases from 1.6 X 10^{-5}T.m^2 to 3.2 X 10^{-3} T.m^2 in 0.12 s.

i. Calculate the magnitude of the induced current [5 marks]

ii. If the resistance of the wire in the coil is 4.8 Ω, what is the induced current? [4 marks]