MACHAKOS UNIVERSITY

University Examinations 2020/2021

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 103: PHYSICS FOR ENGINEERS II

DATE: 12/8/2021 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Constants

Acceleration due to gravity, $g = 9.81\ m/s^2$

Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

Constant of Coulombs law $k = 9 \times 10^9$

Electron charge, $e = 1.6 \times 10^{-19}$ C

Electron mass, $m_e = 9.1 \times 10^{-31}$ kg

Planck's constant, $h = 6.6 \times 10^{-34}$ Js

$1\ Å = 10^{-10}$ m

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) State and explain the two laws of electromagnetic induction. (4 marks)

b) State the mathematical statement, of the Biot-Savart law and define all the terms. (3 marks)

c) Two light conducting spheres each 6 mm diameter and having a mass of 10 mg are suspended from the same point by fine insulating fibers 50 cm long. Due to electrostatic repulsion, the spheres are in equilibrium when 3 cm apart, calculate the following:

(i) force of repulsion between the spheres (4 marks)

(ii) charge on each sphere (3 marks)

(iii) potential of each sphere (3 marks)

d) A closed wire loop in the form of a square of side 4 cm is placed with its plane perpendicular to a uniform magnetic field, which is increasing at the rate of $0.3\ \mathrm{Ts}^{-1}$. The loop has negligible inductance, and a resistance of $2 \times 10^{-3}\Omega$. Calculate the current induced in the loop and explain with the aid of a clear diagram the relation between the direction of the induced current and the direction of the magnetic field.

(5 marks)

e) Calculate the de Broglie wavelength of an electron which has been accelerated from rest through a p.d. of 10^4 V (3 marks)

f) An aircraft with a wing span of 70 m flies with a speed of 2000 m/s at a constant altitude where the vertical component of the earth's magnetic field is 5×10^{-5} T. Calculate the emf that develops between the tips of the wings. (4 marks)

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

a) A coil of radius10 cm and having 20 turns carries a current of 12 A in clockwise directions when seen from the right. If the coil is in a vertical plane find the magnetic field at the center of the coil.

(4 marks)

b) A battery is known to have an EMF of 5.0 V but when a certain voltmeter is connected to it, the reading is 4.9 V. The battery can deliver a current of 0.4 A when connected to a resistance of 12 Ω. Determine the resistance of the voltmeter? (3 marks)

c) Figure 4 represents a cylindrical aluminum bar AB resting on two horizontal aluminum rails which can be connected to a battery to drive a current through AB. A magnetic field, of flux density 0.1 T acts perpendicularly to the paper and into it.

(i) Explain how you can predict the direction in which the rod AB moves if the current flows from A to B. (3 marks)

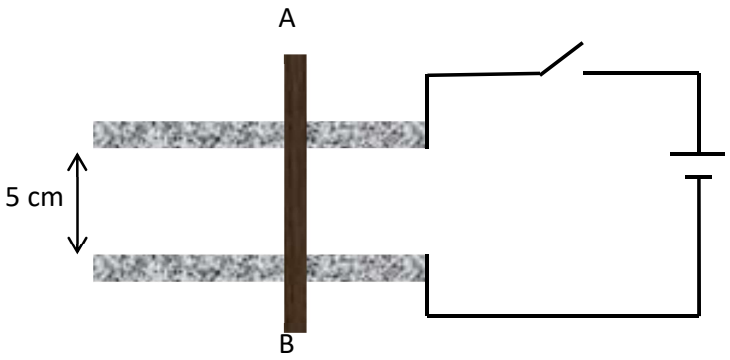

Figure 4

(ii) Calculate the angle to the horizontal to which the rails must be tilted to keep AB stationary if its mass is 0.5 kg, the current in it is 4.0 A and the direction of the field remains unchanged. (5 marks)

d) Four charged particles are placed within a perfect square of length L as shown in Figure 1. A particle with charge $+Q$ is placed half-way way between the middle of $+q$ on the left and the $+3q$ on the right. Calculate the magnitude and direction of the resultant force on $+Q$. (5 marks)

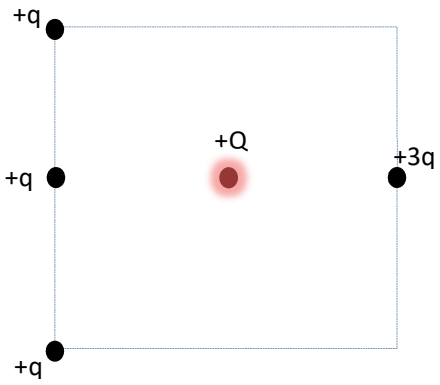

Figure 1

QUESTION THREE (20 MARKS)

a) Distinguish between the following properties of waves

(i) Refraction (2 marks)

(ii) Interference (2 marks)

b) A coil of radius 10 cm and having 20 turns carries a current of 12 A in the clockwise direction when seen from the east. If the coil is in N-S plane. Calculate the magnetic field at the centre of the coil. (4 marks)

c) Calculate the charge on 5 uF capacitor in the circuit shown in Figure 2. (6 marks)

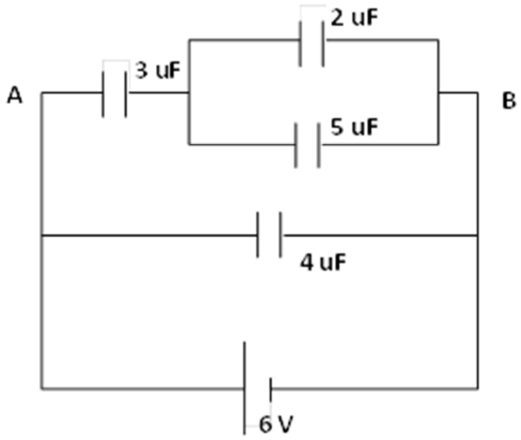

Figure 2

d) A thundercloud has a horizontal lower surface area of 25 km^2 which is 750 m above the earth. Treating the arrangement as a capacitor,

(i) Calculate the electrical energy stored when it's potential is 10^5 V above the earth. (3 marks)

(ii) If the cloud rises to 1250 m what change in electrical energy occurs? (3 marks)

QUESTION FOUR (20 MARKS)

a) Explain what is meant by the following

(i) Coherent waves (2 marks)

(ii) Huygens's principle (2 marks)

b) A beam of light is refracted at the boundary of two media. Using the Huygens principle show how the ratio of the sine of the angle of incidence to the sine of the angle of

refraction is related to the speeds of light in the two media. (6 marks)

c) Two horizontal parallel plates each of area $500\,\text{cm}^2$ are mounted 2 mm apart in a vacuum. The lower plate is earthed and the upper one is given positive charge of 0.05 μC. Neglecting edge effects, Calculate,

(i) Electric field strength between the plates and state the direction the field. (4 marks)

(ii) Capacitance between the two plate (4 marks)

d) State the effect on the fringe separation in interference pattern due to the following changes

(i) Increasing the distance between slits and screen (1 mark)

(ii) Decreasing the distance between the slits (1 mark)

QUESTION FIVE (20 MARKS)

a) The energy level of the hydrogen atom is given by the expression

$$E_n = \frac{2.16\times10^{-18}}{n^2}\ \text{J}$$

Where n is an integer. Calculate the following:

(i) ionization energy of the atom? (3 marks)

(ii) wavelength of the H_α line, which arises from transitions between $n = 3$ and $n = 2$ levels? (4 marks)

b) In a Young's double slit experiment, the interval between the slits is 0.2 mm. For the light of wavelength 6000 Å, interference fringes are formed on a screen at a distance of 0.8 m. Calculate the following:

(i) Distance of the second dark fringe from the central fringe? (4 marks)

(ii) Distance of the second bright fringe from the central fringe? (4 marks)

c) A capacitor is filled with two dielectrics of the same dimensions but different dielectric constants K_1 and K_2, respectively. Determine the capacitance in the arrangement shown in Figure 3 in terms of the dielectric constants and the dimensions. (5 marks)

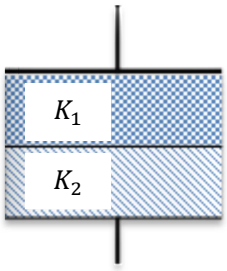

Figure 3