



MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)
BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)
BACHELOR OF SCIENCE (CIVIL ENGINEERING)
ECU103/ECU122: PHYSICS FOR ENGINEERS II

DATE: 14/4/2023

TIME: 11:00 – 1:00 PM

IMPORTANT CONSTANTS

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

Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

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

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

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

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

INSTRUCTIONS:

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

SECTION A

QUESTION ONE (30 MARKS)

- (a) State the following laws of electromagnetic induction giving an illustration in each with a mathematical relation.
- (i) Lenz's law (3 marks)
 - (ii) Faradays law (3 marks)
- (b) Define the following properties of waves
- (i) Interference (2 marks)
 - (ii) Refraction (2 marks)
- (c) State the Biot-Savart law and give its mathematical statement (4 marks)
- (d) An alpha particle accelerated between a pair of parallel plates in a vacuum tube acquires a kinetic energy of 10^3 eV. What is the potential difference between the plates? (4 marks)
- (e) State the law of conservation of charges. (2 marks)
- (f) Two similar and equally charged spheres A and B repel each other with a mutual force of 2×10^{-5} N. A third identical uncharged sphere C is made in contact with A and then with B. If it is then placed at the midpoint between A and B, what is the electric force on C? (4 marks)
- (g) State three factors that affect resistance of a conductor. (3 marks)
- (h) Write the expression for the de Broglie wavelength of an electron in terms of its kinetic energy E , the electron mass m_e , and the Planck constant h . (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

- (a) Two point-charges of $+8 \times 10^{-9} \text{ C}$ and $+24 \times 10^{-9} \text{ C}$ are placed at the corners A and C of a square ABCD having each side 4 cm as shown in Figure 1. Find the resultant electric field intensity at the corner D and the angle of the resultant from the positive x-axis. Assume that the medium is air. (8 marks)

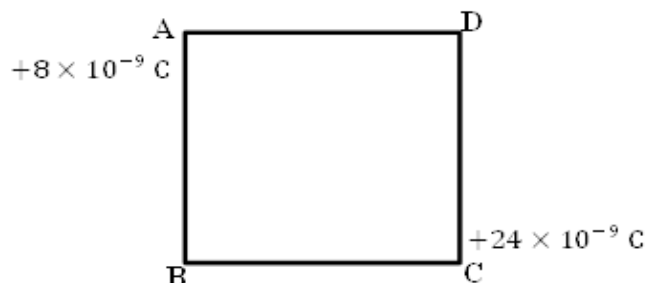


Figure 1

- (b) Two small spheres, each having a mass of 0.1 g are suspended from a point by threads 20 cm long. They are equally charged and they repel each other to a distance of 24 cm. Calculate the charge on each sphere. (4 marks)
- (c) Two capacitors A and B are connected in series across a 200 V dc supply. The p.d. across A is 120 V. This p.d. is increased to 140 V when a $3 \mu\text{F}$ capacitor is connected in parallel with B. Calculate the capacitance of A and B. (8 marks)

QUESTION THREE (20 MARKS)

- (a) State the following principles
- (i) Principle of superposition of waves (2 marks)
 - (ii) The Huygens principle (2 marks)
- (b) State two conditions for an observable interference pattern (2 marks)
- (c) Prove the following laws using the Huygens principle
- (i) Law of reflection (4 marks)
 - (ii) Law of refraction (4 marks)

- (d) In a Young's double slit experiment, the interval between the slits is 0.2 mm. For the light of wavelength $6000 \text{ \AA}$, interference fringes are formed on a screen at a distance of 0.8 m.
- (i) What is the distance of the second dark fringe from the central fringe? (3 marks)
- (ii) What is the distance of the second bright fringe from the central fringe? (3 marks)

QUESTION FOUR (20 MARKS)

- (a) Explain what you understand by the following terms
- (i) Electron volt (2 marks)
- (ii) De Broglie wavelength (2 marks)
- (b) The energy level of the hydrogen atom are given by the expression

$$E_n = \frac{2.16 \times 10^{-18}}{n^2} \text{ J}$$

Where n is an integer

- (i) What is the ionization energy of the atom? (3 marks)
- (ii) What is the wavelength of the H_α line, which arises from transitions between $n = 3$ and $n = 2$ levels? (4 marks)
- (c) Calculate the de Broglie wavelength of an electron which has been accelerated from rest through a p.d. of 10^4 V (4 marks)
- (d) A coil of radius 10 cm and having 20 turns carries a current of 12 A in clockwise directions when seen from the right. The coil is in a vertical plane. Find the magnetic field at the center of the coil. (5 marks)

QUESTION FIVE (20 MARKS)

- (a) What is meant by the following terms
- (i) Magnetic field (2 marks)
- (ii) Magnetic flux (2 marks)
- (b) Write down the expressions for the following situations:
- (i) The magnetic field B at a distance r from a long straight wire carrying a current I . (2 marks)
- (ii) The force on a straight wire of length l placed perpendicular to a magnetic field B and carrying current I . (2 marks)

- (c) A capacitor is filled with two dielectrics of the same dimensions but different dielectric constants K_1 and K_2 , respectively. Find the capacitance in the arrangement shown in Figure 2 in terms of the dielectric constants and the dimensions. (6 marks)

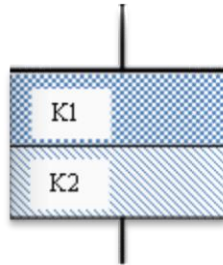


Figure 2

- (d) An electrical network is arranged as shown in Figure 3. Find the current in the branch BE. (6 marks)

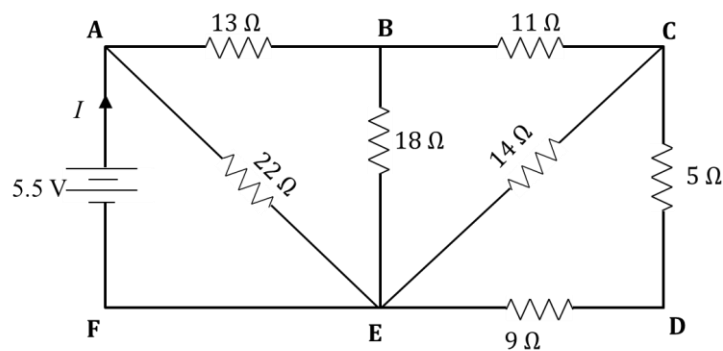


Figure 3