



MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAMINATION FOR
DEGREE IN BACHELOR OF EDUCATION (SCIENCE), BACHELOR OF SCIENCE
(MATHS), BACHELOR OF SCIENCE IN TELECOMMUNICATION AND

INFORMATION TECHNOLOGY

SPH 201: ELECTRICITY AND MAGNETISM II

DATE: 25/9/2019

TIME: 2:00 – 4:00 PM

INSTRUCTIONS TO CANDIDATES

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

Question 1 carries **30** marks and the others carry **20** marks each.

YOU MAY USE:

You may need to use the following constants

$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$; $K = 1/(4\pi\epsilon_0) = 8.99 \times 10^9$, Electron charge, $q_e = -1.6 \times 10^{-19} \text{ C}$, Proton charge, $q_p = +1.6 \times 10^{-19} \text{ C}$, Mass of a proton, $M_p = 1.67 \times 10^{-27} \text{ Kg}$ Mass of an electron, $M_e = 9.11 \times 10^{-31} \text{ Kg}$, $\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$, $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$, $G = 6.67 \times 10^{-11} \text{ N.m}^2. \text{ Kg}^{-2}$.

QUESTION ONE

- a) State and write the mathematical expression for Gauss's law. 2 marks
- b) Three charges $-3\mu C$, $12\mu C$ and $-4\mu C$ are placed in a sphere of radius $r=3\text{cm}$. Determine the electric field associated with them. 3 marks
- c) Sketch a graph of the magnitude of electric charge on either plate of a capacitor versus the magnitude of the potential difference between the plates. What does its slope indicate? And based on this curve, provide the two SI units representing this relationship. 4 marks
- d) For a parallel plate capacitor, show that the energy density in any electric field is proportional to the square of the magnitude of the electric field at a given point. 4 marks
- e) Distinguish between impedance and resistance. 2 marks
- f) A transmitting circuitry contains a coil with an inductance of 3 mH and is to generate a signal of 2 MHz . Calculate the value of the used capacitor. 4 marks
- g) A 50 turns coil with a radius of 25cm carries a current of 4.5A .
- i) What is the magnitude of its magnetic dipole moment? 2 marks
- ii) What is a torque on the coil if it is in a uniform magnetic field of 0.02T with an angle of 20° between moment and field? 3 marks
- h) A circuit consist of an inductor of $200\mu H$ and resistance 10Ω in series with a variable capacitor and a 10V , 2MHz supply. Calculate;
- i) The capacitance that gives resonance 2 marks
- ii) The p.d's across the inductor at resonance 2 marks
- i) State Ampere's law 2 marks

QUESTION TWO

- a) Define a ballistic galvanometer and describe how it is calibrated. 5 marks
- b) A sinusoidal voltage of frequency $f=60\text{Hz}$ and peak value 150V is applied to a series R-L circuit where $R=20\Omega$ and $L=40\text{mH}$.
- i) Compute the period T , ω , χ_L , Z and ϕ 5 marks
- ii) Compute the amplitudes I , V_R , V_L 3 marks
- iii) Compute the instantaneous values i , V_R , V_L at $t = \frac{T}{6}$. 3 marks
- iv) Compute the I_{RMS} , V_{RMS} and the average power into the circuit. 4 marks

QUESTION THREE

- a) (i) What is a capacitor 1 mark
(ii) What happens when you half the plate area and double the voltages of a capacitor? 2 marks
- b) A coaxial cable connecting a TV to an antenna socket is 3 m long. The inner conductor has an outer radius of 0.5 mm, the outer conductor has an inner radius of 3 mm. The space between the conductors is filled with plastic with $\kappa = 2.6$. Derive the expression to be used and use it to determine the capacitance of this cable? 8 marks
- c) (i) State Bio-Savart law for a current element 2 marks
(ii) Consider a straight infinitely long wire carrying a steady current I . Using Biot-Savart law, derive the expression for magnetic field at a point P at a distance r from the wire as shown below in figure. 7 marks

QUESTION FOUR

- a) Using Gauss' law, find the electric field due to a uniformly charged sphere of radius R with a surface charge density of ρ at a point P , distance r ;
- i) $R \gg r$ 2 marks
ii) $R = r$ 2 marks
iii) $R \ll r$ 2 marks
- b) An electron in a television picture tube moves toward the front of the tube with a speed of 8.0×10^6 m/s along the x axis. Surrounding the neck of the tube are coils of wire that create a magnetic field of magnitude 0.025 T, directed at an angle of 60° to the x axis and lying in the x - y plane. Calculate the magnetic force on the electron and its direction. 5 marks
- d) Using Gauss' law, show that for a parallel-plate capacitor with area of the plates, A and plate separation d ; 9 marks

$$C = \epsilon_0 \frac{A}{d}$$

QUESTION FIVE

- a) A helicopter is hovering with its 5.0 m long blades rotating at 200 rpm. The local magnetic field is directed upwards at approximately 60° to the horizontal and has a magnitude of 50 mT. What is the induced emf between the hub (where the blades join to the helicopter) and the tips of the blades? (Hint – the emf induced across a short length, Δl , of conductor is the rate at which it cuts through magnetic flux.) 8 marks
- b) Show that for a positively charged particle moving in a uniform magnetic field **B** with the initial velocity vector **V** of the particle perpendicular to the field;
- i) The radius of the orbit **R** is directly proportional to the velocity **V** 4 marks
 - ii) its period of revolution is inversely proportional to **B** 4 marks
 - iii) An electron with K.E. of 10^3 eV moves perpendicular to the lines of uniform field **B**= 10^{-3} T . Calculate the period and the radius of the orbit 4 marks