MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2018/2019 ACADEMIC YEAR
THIRD YEAR SECOND SEMESTER

SCHOOL OF SCIENCE
UNIVERSITY EXAMINATIONS FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE) AND BACHELOR OF SCIENCE

COURSE CODE: PHY 3220
COURSE TITLE: ELECTROMAGNETISM

DATE: 24TH APRIL 2019 B **TIME: 0830HRS-1030HRS**

INSTRUCTIONS

- Answer Question ONE and any other TWO.
- Use of sketch diagrams where necessary and brief illustrations are encouraged.
- Read the instructions on the answer booklet keenly and adhere to them.

Physical constants

1 eV= 1.6 x 10-19 J

Mass of proton = 1.7 X 10-27 Kg

Charge of proton = 1.6 X 10-19C2

QUESTION ONE

(a)Define the term ‘Displacement current’. (1 mark)

(b) State the Faraday’s law of electromagnetic induction and express it mathematically. (2marks)

(c) Write the Maxwell’s equations and state their physical interpretations. (4 marks)

(d) State two features of Electromagnetic waves (2marks)

(e) Consider the circuit in Figure below, suppose the circuit elements have the following values: $\epsilon = 12.0$ V, R = 6.00 Ω, and L = 30.0 mH.

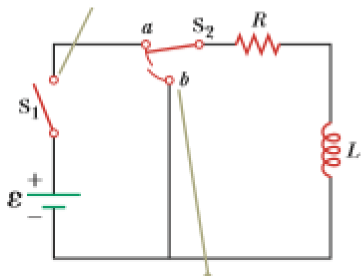

figure 1

(i) Find the time constant of the circuit.

(ii) Switch S2 is at position a, and switch S1 is thrown closed at t = 0. Calculate the current in the circuit at t = 2.00 ms. (4 marks)

(f) Two straight, parallel super conducting cables are kept 5.0mm apart and are intended to carry equal amount of current of 15000A in opposite directions. The mechanical strength of the material of the cable is given as 1.5x 103 N/m, should we worry about the mechanical strength of these cables under operations? (3marks)

(g) Calculate the magnetic field of a long, straight wire carrying a current of 10A at a distance 8mm from the wire. (3 marks)

(h) Find the self-inductance of a solenoid that has a cross-sectional area of 2 cm^2, a length of 20 cm and 1000 turns of wire. (3marks)

(i) A flat coil of wire with 50 turns and a cross-sectional area of 50 cm2 is placed in a magnetic field with its plane perpendicular to the magnetic field B = 0.45T. If the field is changing at the rate of 0.04T/s, find the magnitude of induced e.m.f at the terminals of the coil. (4marks)

(j) A long solenoid of radius R has n turns of wire per unit length and carries a time varying current that varies sinusoidally as $I = I_{max} \cos\omega t$, where I_{max} is the maximum current and v is the angular frequency of the alternating current source

(i) Determine the magnitude of the induced electric field outside the solenoid at a distance r > R from its long central axis.

(ii) What is the magnitude of the induced electric field inside the solenoid, a distance r from its axis? (4 marks)

QUESTION TWO

(a) Starting with integral forms, write down all the differential forms of the time-harmonic Maxwell's electromagnetic (EM) field equations, defining all the symbols used. (5 marks)

(b) Consider once again the RL circuit shown in Figure 1, with switch S_2 at position a and the current having reached its steady-state value. When S_2 is thrown to position b, the current in the right-hand loop decays exponentially with time according to the expression $I = I_i\, e^{\frac{-t}{\tau}}$, where $I_i = \epsilon/R$ is the initial current in the circuit and $\tau = L/R$ is the time constant. Show that all the energy initially stored in the magnetic field of the inductor appears as internal energy in the resistor as the current decays to zero. (5 marks)

(c) Consider a circular loop of wire of radius R, located in the YZ plane and carrying a steady current I. Calculate the magnetic field at an axial point P at a distance x from the centre of the loop. (10 marks)

QUESTION THREE

(a)(i) Find an expression for magnetic induction B, by applying Ampere's law to determine the magnitude of the field inside an infinitely long and tightly wound solenoid. (3 marks)

(ii) Find an expression for the total magnetic field at a point P, located at a distance "a" from a thin, straight wire carrying conductor placed along the x-axis. (7 marks)

(b) Verify that both the electric and magnetic fields satisfy the one dimensional wave equation and show that it's solution is of the form $\psi = x \pm vt$ (10 marks)

QUESTION FOUR

(a) Deduce a mathematical statement for Poynting Vector using Maxwell's general electromagnetic (EM) field equations, and define the various terms obtained. (10 marks)

(b) At the upper surface of the earth's atmosphere, the time –averaged magnitude of the Poynting vector $< s >= 1.35 \times 10^3 W/m^2$, is referred to as the solar constant.

(i) Assuming that the sun's electromagnetic radiation is a plane sinusoidal wave, what are the magnitudes of the electric fields?

(ii) What is the total time-averaged power radiated by the sun? The mean sun-earth distance is $R = 1.5 \times 10^{11}$m. (5 marks)

(c) Derive Ampere's law in integral form based on Biot-Savart law for an infinitely long wire. (5 marks)

//END