RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

Bachelor of Science in Applied Sciences

First Year – Semester II Examination – Jan / Feb 2023

PHY 1203 - FUNDAMENTALS OF ELECTROMAGNETISM

Time: Two (02) hours

Answer **all four (04)** questions

Symbols have their usual meaning

Use of a non-programmable calculator is permitted.

Some fundamental constants and physical data;

Electron mass $m_e = 9.1 \times 10^{-31}$ kg, Electron charge $e = 1.6 \times 10^{-19}$ C,

Speed of light in vacuum $c = 3.0 \times 10^{8}$ m s^{-1}, Electron volt 1 eV $= 1.6 \times 10^{-19}$ J,

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2}, $\frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^{9}$ N m^2 C^{-2},

Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}.

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1. a) State Coulomb's Law. (05 marks)

   b) Two point charges Q_1 and Q_2 are 3 m apart, and their combined charge is 20 μC. Determine the values of the two charges if,

      i. one repels the other with a force of 0.075 N.

      ii. one attracts the other with a force of 0.525 N.

      (08 marks)

Contd.....

c) When is it valid to approximate a charge distribution by a "point charge"? (05 marks)

d) What effect does an isotropic homogeneous medium have on Coulomb's law for charges embedded in it? (07 marks)

2. a) State Ampere's Circuital Law. (04 marks)

b) Five very long straight, insulated wires are closely bound together to form a small cable. Currents carried by the wires are $I_1 = 20$ A, $I_2 = -6$ A, $I_3 = 12$ A, $I_4 = -7$ A, $I_5 = 18$ A. Use Ampere's law to determine the magnetic field B at a distance 10 cm from the cable.
(06 marks)

c) A straight wire is lined up in the north-south direction. A compass needle is place above the wire. When the current is turned on, the North Pole of the compass is deflected toward the west. In which direction are electrons in the wire moving? Justify your answer.
(09 marks)

d) In electronics, wires that carry equal but opposite currents are often twisted together to reduce their magnetic effect at distant points. Why is this effective?
(06 marks)

3. a) State Faraday's Law of induction.
(05 marks)

b) i. A coil is wrapped with 200 turns of wire on the perimeter of a square frame of sides 18 cm. Each turn has the same area, equal to that of the frame and the total resistance of the coil is $2\,\Omega$. A uniform magnetic field is turned on perpendicular to the plane of the coil. If the field changes linearly from 0 to 0.5 Wb/m^2 in a time of 0.8 s, determine the magnitude of the induced emf in the coil while the field is changing.
(08 marks)

ii. What is the magnitude of the induced current in the coil while the field is changing?
(05 marks)

c) How would you position a flat loop of wire in a changing magnetic field so that there is no induced emf in the loop? Justify your answer.
(07 marks)

4. a) Use Gauss' Law to verify that a charge Q, uniformly distributed over the surface of a sphere, is equivalent externally to a point charge Q at the center of the sphere.

(08 marks)

b) A metal bottle is suspended by a silk thread carrying a positive charge (not uniformly distributed). At a certain point very near the surface of the bottle, the electric field has a value E = 600 kV/m. Evaluate the surface charge density σ near that point.

(11 marks)

c) If potential V is constant throughout a given region of space, what can you say about electric field $\boldsymbol{E}$ in that region? Explain.

(06 marks)

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