RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester II Examination – October/November 2017

PHY1203 – FUNDAMENTALS OF ELECTROMAGNETISM

Time: Two (02) hours

Answer any four (04) questions

Use of a non-programmable calculator is permitted.

Some fundamental constants ;

Electron mass $m_e = 9.1 \times 10^{-31}$ kg,
Speed of light in vacuum $c = 3.0 \times 10^{8}$ m s^{-1},
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2},
Acceleration due to gravity $g = 9.8$ m s^{-2},
Gravitational constant $G = 6.67 \times 10^{-34}$ N m^2 C^{-2},
Avogadro's Number = 6.022×10^{23} (g mol)$^{-1}$
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}.
Electron charge $e = 1.6 \times 10^{-19}$ C,
Electron volt 1 eV $= 1.6 \times 10^{-19}$ J,

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1. (a) State Coloumb's law. **(05 marks)**

(b) Two small silver spheres with a mass of 100 g, are separated by a distance of 1 m. Calculate the fraction of the electrons in one sphere that must be transferred to the other in order to produce an attractive force of 10^4 N between the spheres. Note that the number of electrons per atom of silver is 47, and the atomic mass of silver is 107.87.

(10 marks)

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

(05 marks)

(d) Assume that someone proposes a theory that says people are bound to the earth by electric forces rather that by gravity. How could you prove this theory wrong?

(05 marks)

Contd.

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

(b) i. Using the Ampere's Circuital Law, show that the magnetic field B inside an ideal solenoid which carries a current I can be given by $B = \mu_0 nI$; where n is the number of turns per unit length. **(06 marks)**

ii For a research project, a student needs a solenoid that produces an interior magnetic field of 0.03 T. She decides to use a current of 1.0 A and a wire of 0.5 mm in diameter. She winds the solenoid as layers on an insulating form of 1.0 cm in diameter and 10.0 cm in length. Determine the number of layers of wire needed and the total length of the wire. **(10 marks)**

(c) Is the magnetic field due to a current loop uniform? Explain. **(05 marks)**

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

ii. A large circular loop of wire lies in the horizontal plane. A bar magnet is dropped through the loop. Describe the emf induced in the loop, if the axis of the magnet remains horizontal as it falls. What would be the case if the axis of the magnet remains vertical as it falls? **(05 marks)**

(b) To monitor the breathing of a patient, a thin belt is girded about the patient's chest. The belt is a 200-turn coil. During inhalation, the area within the coil increases by 39 cm^2. The earth's magnetic field is 50 μT and makes an angle of 28 degrees with the plane of the coil. If the patient takes 1.8 s to inhale, find the average induced emf in the coil while the patient is inhaling. **(10 marks)**

(c) Are the occupants of a steel-frame building safer than those in a wood-frame house during an electrical storm or vice versa? Explain. **(05 marks)**

4. (a) i. State Gauss's Law **(04 marks)**

ii. Use Gauss' law to explain why the electric field lines must begin and end on electric charges. **(04 marks)**

(b) A long coaxial cable consists of an inner cylindrical conductor of radius r_a and an outer coaxial cylinder of inner radius r_b and outer radius r_c. The outer cylinder is mounted on insulating supports and has no net charge. The inner cylinder has a uniform positive charge λ per unit length.

Contd.

i. Calculate the electric field at any point between the cylinders and electric field at any external point. **(06 marks)**

ii. Sketch a graph of the magnitude of the electric field E as a function of the distance r from the axis of the cable from $r = 0$ to $r = 2r_c$ **(08 marks)**

(c) How can you ensure that the electric potential in a given region of space will have a constant value? **(03 marks)**

5. Justify your answers

(a) It is impossible for a time independent magnetic field to alter the speed of a charged particle. **(05 marks)**

(b) Is it likely that a situation could exist where there is a high voltage without having a high current at the same time? **(05 marks)**

(c) Auroras are visible on the poles and not on the equator. **(05 marks)**

(d) A light, uncharged metal sphere suspended from a thread is attracted to a charged rubber rod. Why is the sphere repelled by the rod after touching the rod? **(05 marks)**

(e) If a charged particle moves in a straight line through some region of space, what can you say about the magnetic field in that region? **(05 marks)**

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