RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year – Semester II Examination – February / March 2019

PHY 1203 - FUNDAMENTALS OF ELECTROMAGNETISM

Time: Two (02) hours

Answer any **four** questions
Use of a non-programmable calculator is permitted.
Unless otherwise specified, symbols and notations have their usual meaning.

Some fundamental constants and physical data;

Electron mass, $m_e = 9.1 \times 10^{-31}$ kg,
Speed of light in vacuum, $c = 3.0 \times 10^{8}$ m s^{-1},
Avogadro's number, $N_A = 6.022 \times 10^{23}$ mol^{-1},
Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2},
Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}.

Planck's constant, $h = 6.626 \times 10^{-34}$ J s,
Electron charge, $e = 1.6 \times 10^{-19}$ C,
Electron volt, $eV = 1.6 \times 10^{-19}$ J,
$\frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^{9}$ N m^2 C^{-2},

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

(b) A charge q is uniformly distributed throughout a nonconducting sphere of radius R.
i. Show that the potential at a distance a from the center, where $a < R$, is given by

$$V = \frac{q(3R^2 - a^2)}{8\pi\varepsilon_0 R^3}$$ (10 marks)

ii. "V is not zero at the center of the sphere". Justify this statement. (04 marks)

(c) If potential V equals a constant throughout a given region of space, then what can you say about the electric field E in that region? Explain. (06 marks)

Contd.

2. (a) State Coloumb's law. (05 marks)

(b) Two identical small metal spheres attract each other with a force of 0.0853 N. The distance between the spheres is 1.19 m. The spheres are then brought into electrical contact with each other. When returned to a separation of 1.19 m, the spheres repel each other with a force of 0.0196 N. Find the original charge on each sphere. (14 marks)

(c) When is it valid to approximate a charge distribution by a "point charge"? (06 marks)

3. (a) State Faraday's Law of induction. (06 marks)

(b) A plane loop of wire of area A is placed in a region where the magnetic field is perpendicular to the plane. The magnitude of B varies with time according to the expression $B = B_0 e^{-\alpha t}$, where α is a constant.

i. Find the induced emf in the loop as a function of time. (05 marks)

ii. What is the maximum emf? (05 marks)

(c) i. A large circular loop of wire lies in a horizontal plane. A bar magnet is dropped through the loop. If the axis of the magnet remains horizontal as it falls, describe the emf induced in the loop. How is the situation altered if the axis of the magnet remains vertical as it falls? (05 marks)

ii. What is the difference between the magnetic flux and the magnetic field? (04 marks)

4. (a) State Ampere's Circuital Law. (05 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. He decides to use a current of 1.0 A and a wire of 0.5 mm in diameter. He 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. (09 marks)

(c) 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? (05 marks)

Contd.

5. Justify the following;

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

(b)The occupants of a steel-frame building are safer than those in a wood-frame house during an electrical storm. (05 marks)

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

(d) A thin stream of water bends toward a negatively charged rod. When a positively charged rod is placed near the stream it will bend in the same direction. (05 marks)

(e) It is possible for an electric field to exist in empty space. (05 marks)

.....END.....