RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
First Year – Semester II Examination – March / April 2014

PHY 1203 - FUNDAMENTALS OF ELECTROMAGNETISM

Answer any **four** questions — Time: Two hours

Use of a non-programmable calculator is permitted.

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},
Acceleration due to gravity, $g = 9.8$ m s^{-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},
Proton mass, $m_p = 1.67 \times 10^{-27}$ kg,

1. (a) State Coulomb's Law [6 marks.]

(b) A charge Q is placed at each of two opposite corners of a square. A charge -q is placed at each of the other two corners.

i. If the resultant electrical force on Q is zero, how are Q and q related? [6 marks]

ii. Could q be chosen to make the resultant force on every charge zero? [6 marks]

(c) A charged rod attracts bits of dry cork dust which, after touching the rod, often jump violently away from it. Explain. [7 marks]

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2. (a) State Ampere's Circuital Law. [5 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 $B = \mu_0 nI$. n is the number of turns per unit length. [6 marks]

ii Some superconducting alloys at very low temperature can carry very high currents. For example, Nb_3Sn wire at 10 K can carry 10^3A and maintain its superconductivity. Determine the maximum B which can be achieved in a solenoid of length 25 cm, if 1000 turns of Nb_3Sn wire are wrapped on the outside surface. [7 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? [7 marks]

3. (a) State Faraday's Law of induction. [6 marks]

(b) Two inductances L_1 and L_2 are connected in series and are separated by a large distance.
i. Show that the equivalent inductance L is $L_1 + L_2$. [4 marks]

ii. Why must their separation be large? [2 marks]

(c) i. A 10 H inductor carries a steady current of 2 A. How can a 100 V self-induced emf be made to appear in the inductor? [4 marks]

ii. What is the difference between the magnetic flux and the magnetic field? [4 marks]

iii. A loop of wire is placed in a uniform magnetic field. What orientation of the loop is the magnetic flux a maximum? What orientation of the loop is the magnetic flux zero? [5 marks]

4. (a) State Gauss' Law [5 marks]

(b) Starting with Gauss' law, calculate the electric field due to an isolated point charge q and show that the Coulomb's law follows from this result. [6 marks]

(c) The following charges are located inside a submarine: +5 μC, -9 μC, +27 μC and -84 μC.

i. Calculate the net electric flux through the submarine. [5 marks]

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ii. Compare the number of electric field lines leaving the submarine with the number entering it. [5 marks]

iii. If there are more electric field lines leaving a Gaussian surface than entering the surface, what can you conclude about the net charge enclosed by that surface? [4 marks]

5. Write **short notes** on the following.

(a) Eddy currents [5 marks]

(b) The Van de Graaff generator [5 marks]

(c) Corona discharge [5 marks]

(d) Cosmic rays [5 marks]

(e) Wheatstone bridge [5 marks]

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