RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year – Semester II Examination – April / May 2015

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},
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. [06 marks]

(b) A thin metallic spherical shell of radius a carries a charge q_a. Another thin metallic spherical shell of radius b ($b > a$) concentric with it carries a charge q_b. Use Gauss's law to find the electric field strength at radial points r where

i. $r < a$;
ii. $a < r < b$;
iii. $r > b$.
iv. Discuss the criterion to determine how the charges are distributed on the inner and outer surfaces of each shell. [12 marks]

(c) Would Gauss's law hold if the exponent in Coloumb's law were not exactly two? Explain. [07 marks]

Contd.

2. (a) Show that the charged particle q with a mass of m moves in a circle, whose plane is perpendicular to the magnetic field has a radius $r = \frac{mv}{qB}$; where v is the velocity of the charged particle which is perpendicular to the uniform field of magnetic induction B. [08 marks]

(b) A cyclotron has an oscillatory frequency (angular frequency) of 12×10^6 cycles / sec and a "Dee" radius of 0.53 m.

i. What value of magnetic induction B is needed to accelerate deuterons? Charge of a deuteron is similar to that of an electron and mass is 3.3×10^{-27} kg. [05 marks]

ii. Calculate the kinetic energy of the deuterons. [05 marks]

(c) "*The cyclotron fails to operate at high energies.*" Do you agree with the above statement? Explain. [07 marks]

3. (a) State Faraday's Law of induction. [05 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 $\boldsymbol{B}$ varies with time according to the expression $B = B_0 e^{-\alpha t}$, where α is a constant. That is, at $t = 0$ the field is B_0, and for $t > 0$, the field decreases exponentially with time.

i. Find the induced emf in the loop as a function of time. [04 marks]

ii. What is the maximum emf? [04 marks]

(c) i. A large circular loop of wire lies in the 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? [04 marks]

ii. What is the difference between the magnetic flux and the magnetic field? [04 marks]

iii. Are the occupants of a steel-frame building safer than those in a wood-frame house during an electrical storm or vice versa? Explain. [04 marks]

Contd.

4. (a) State Ampere's Circuital Law. [06 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. A single-turn square loop of wire, 2.0 cm on a side, carries a counterclockwise current of 0.2 A. The loop is inside a solenoid, with the plane of the loop perpendicular to the magnetic field of the solenoid. The solenoid has 30 turns per centimeter and carries a counter clock wise current of 15.0 A. Find the force on each side of the loop and the torque acting on it. [07 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? [06 marks]

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

(a) Helmholtz coils [05 marks]

(b) Meter's bridge [05 marks]

(c) Corona discharge [05 marks]

(d) Cosmic rays [05 marks]

(e) Electric shock [05 marks]

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