RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester II Examination – November/December 2016

PHY1203 – FUNDAMENTALS OF ELECTROMAGNETISM

Time: Two (02) 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, 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 = 1.6×10^{-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},

Acceleration due to gravity $g = 9.8$ m s^{-2}, Proton mass $m_p = 1.67 \times 10^{-27}$ kg,

Gravitational constant $G = 6.67 \times 10^{-34}$ N m^2 C^{-2},

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

---

1. (a) What are the similarities and differences between Newton's Universal Law of Gravitation, $F = G\frac{m_1 m_2}{r^2}$, and Coulomb's Law, $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$? **(04 marks)**

(b) The electron and the proton of a hydrogen atom are separated (on the average) by a distance of approximately 5.3×10^{-11} m. Find the magnitude of the electrical force between the two particles and show that the gravitational force between charged atomic particles is negligible compared with the electrical force.

(08 marks)

Contd.

(c) Calculate the distance between two protons if the electrical repulsive force acting on either one is equal to its weight? **(06 marks)**

(d) Would life be different if the electron was positively charged and the proton was negatively charged? Does the choice of signs have any bearing on physical and chemical interactions? Explain. **(07 marks)**

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 A superconducting solenoid is to be designed to generate a magnetic field of 10 T. Determine the required current, if the solenoid windings has 2000 turns per meter. Also, calculate the force per unit length on the solenoid windings by this magnetic field. **(08 marks)**

(c) Is Ampere's law valid for all closed paths surrounding a conductor? Why is it difficult for calculating magnetic field for all such paths? **(07 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) i. 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 the magnetic field **B** varies in time according to the expression $B = B_0 e^{-at}$, where a is a constant. That is the field decreases exponentially with time. What is the induced emf in the loop as a function of time? **(06 marks)**

ii. Calculate the maximum induced emf. **(04 marks)**

(c) A sheet of copper is placed perpendicular to a magnetic field. If we attempt to pull it out of the field or push it further in, an automatic resisting force appears. Explain its origin. **(05 marks)**

Contd.

4. (a) i. State Gauss's Law **(05 marks)**

ii. Use Gauss' law to explain why the electric field lines must begin and end on electric charges. **(05 marks)**

(b) i. Five charges are placed in a closed box. Each charge (except the first) has a magnitude which is twice that of the previous one placed in the box. If the net electric flux through the box after all charges have been placed in the box is 4.8 x 10^7 N m^2 C^{-1}, what is the magnitude of the smallest charge in the box? Note that all the charges have the same sign. **(06 marks)**

ii. Does the answer depend on the size of the box? Explain. **(04 marks)**

(c) How can you ensure that the electric potential in a given region of space will have a constant value? **(05 marks)**

5. Justify your answers

(a) A comb can sometimes be given an electric charge by running it through your hair. The charged comb will then attract small pieces of paper. Will the charged comb also be attracted to magnets? **(05 marks)**

(b)You are an astronaut stranded on a planet with no test equipment or minerals around. The planet does not even have a magnetic field. You have two bars of iron in your possession; one is magnetized, one is not. How could you determine which is magnetized? **(05 marks)**

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

(d) Electromagnetic fields from household devices especially those with electric motors, are usually stronger than fields from nearby power lines when the fields are measured in the home. How can you account for this phenomenon? **(05 marks)**

(e)Is it credible that there could be an unknown universe in which there are charged bodies, but no electric fields? **(05 marks)**

...END...