RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year - Semester I Examination – June/July 2018

PHY 2102 – ELECTROMAGNETISM

Time: One (01) hour

Answer any two questions

Use of a non-programmable calculator is permitted.
Symbols have their usual meaning.

Some fundamental constants and physical data;
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}\ N\ A^{-2}$,
Speed of light in vacuum $c = 3.0 \times 10^{8}\ m\ s^{-1}$,
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$.
Useful expressions;

$$\vec{\nabla} = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z},\quad \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial}{\partial z^2},\quad \nabla \times (\nabla \times A) = \nabla(\nabla \cdot A) - \nabla^2 A.$$

1. a) Show that at a given instant the ratio of the electric field to the magnetic field of an electromagnetic wave equals the speed of light. i. e. $\frac{E}{B} = \frac{E_m}{B_m} = C$

(10 marks)

b) Prove that the intensity of an electromagnetic wave is given by $\frac{E_m^2}{2\mu_0 C}$.

(15 marks)

c) At one location of the earth, the rms value of the magnetic field due to solar radiation is 1.8 μT. Calculate

i. the average electric field due to solar radiation at this location. (07 marks)

Contd.

ii. the average energy density of the electromagnetic radiation at this location due to solar radiation. (07 marks)

iii. the magnitude of the Poynting vector for the solar radiation. (06 marks)

iv. The sun delivers about 1000 W/m^2 of electromagnetic radiation to the earth's surface. Compare the value obtained in part iii to this value. Explain the reasons for the difference if there is any. (05 marks)

2. a) i. Describe the behavior of a series RLC circuit for the cases $\chi_C > \chi_L$ and $\chi_C < \chi_L$. (10 marks)

ii. Discuss the phenomenon of resonance in series RLC circuit. (10 marks)

iii. A resistor-inductor-capacitor combination R_1, L_1, C_1 connected in series exhibits resonance at the same frequency as a second combination R_2, L_2, C_2 connected in series. If the two combinations are now connected in series, at what frequency would the whole circuit resonate? Assume that the inductors are far apart. (15 marks)

b) i. What is it meant by the Quality factor (Q) of a circuit? (05 marks)

ii. Explain how the quality factor is related to the response characteristics of a receiver. (05 marks)

iii. Which variable most strongly determines the quality factor? (05 marks)

3. a) i. State Gauss's Divergence theorem. (06 marks)

ii. Using Stoke's theorem and the Gauss's Divergence theorem prove that the divergence of the curl of a vector function $\vec{F}$ is zero. (10 marks)

b) i. Write the Maxwell's equations and solve them in free space. (10 marks)

ii. Prove the following; $\nabla(\nabla \cdot \vec{E}) - \nabla^2 \vec{E} = -\mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}$. Use the Maxwell's equation in free space to show $\nabla^2 \vec{E} = -\mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}$ and $\nabla^2 \vec{H} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial t^2}$. (12 marks)

iii. An electromagnetic wave propagates in a ferrite material having $\varepsilon_r = 10$ and $\mu_r = 1000$. Calculate the speed of propagation and the wavelength of the wave of frequency 100 MHz. (12 marks)

-End-