RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year - Semester I Examination – September / October 2019

PHY 2102 – ELECTROMAGNETISM

Time: One (01) hour

Answer any two questions

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

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;

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

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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 C. 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) The magnetic field of an electromagnetic wave is described as follows:
   $\vec{B} = B_0 \sin(kx - \omega t)\,\hat{j}$.

   i. What is the wavelength λ of the wave? **(03 marks)**

   ii. Write an expression for the electric field $\vec{E}$ associated with this wave. **(05 marks)**

Contd.

iii. What is the direction and the magnitude of the Poynting vector associated with this wave? **(08 marks)**

iv This wave is totally reflected by a thin conducting sheet lying in the y-z plane at x = 0. What is the resulting radiation pressure on the sheet? In the total reflection, the radiation pressure is equal to two times the intensity of the wave divided by the velocity of light. **(09 marks)**

2. a) i. What is it meant by inductive reactance and capacitive reactance in terms of the rms values of the voltage and current? Show that these can also be expressed in terms of maximum voltage and current. **(10 marks)**

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

iii. It is desired to set up an un-driven LC circuit in which the capacitor is originally charged to a difference of potential of 100 V. What are the values of L and C for the maximum current to be 10 A, and the oscillation frequency to be 1000 Hz? **(15 marks)**

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

ii. Prove that Q is the factor by which the applied voltage is magnified across L and C in series RLC circuit at resonance. **(10 marks)**

3. a) i. State Stoke's theorem. **(06 marks)**

ii. Using Stoke's theorem, prove that the curl of the gradient of a scalar Φ is zero. **(10 marks)**

b) i. Write the Maxwell's equations and explain the significance of each equation. **(16 marks)**

ii. Using the 1st Maxwell's equation, show that one could obtain the Laplace's equation for a potential V in free space. **(08 marks)**

c) i. If $\Phi(x, y, z) = 3x^2y - y^3x^2$, calculate the gradient Φ at the point (1,-2,-1). **(05 marks)**

ii. If $\vec{A} = x^2s\hat{\imath} - 2y^3s^2\hat{\jmath} + xys\hat{k}$, calculate $\nabla.\vec{A}$ at the point (1,-1,1). **(05 marks)**

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