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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

Bachelor of Science in Applied Sciences
Second Year - Semester II Examination – Jan/Feb 2023

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;

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

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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. 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 $\frac{E_m^2}{2\mu_0 C}$. **(12 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 wave length (λ) of the wave? **(03 marks)**

Contd.

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

iii. What is the direction and the magnitude of the Poynting vector associated with this wave? **(06 marks)**

d) Television frequencies are of the order of 100 MHz, while radio frequencies are of the order 1 MHz. Using these as typical frequencies, find the ratio of the emf generated in a loop antenna by a television wave to that generated by a radio wave if both have equal electric field intensities.

(14 marks)

2. a) i. What is 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. The sum of the peak voltages across each of the elements in a series RLC circuit is usually greater than the peak applied voltage. Doesn't this violate Kirchoff's voltage law? Explain. **(10 marks)**

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

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

ii. Prove that the voltage magnification of a RLC circuit is equal to its Q 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 with the use of integral forms.

(16 marks)
Contd.

ii. How do Maxwell's equations imply that the electromagnetic waves exist in free space and that light is such a wave? **(08 marks)**

iii. Suppose magnetic monopoles did exist. What form would Maxwell's equations take? Justify your answer. **(10 marks)**

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