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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Second Year - Semester I Examination – October/November 2014

PHY 2102 - Electromagnetism

Answer any two questions — Time: One hour

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 $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$,
$\vec{\nabla} = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}$.

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(1) (a) i. State Gauss's Divergence theorem. [10 pts.]

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. [15 pts.]

(b) i. Write the Maxwell's equations and explain the physical significance of each equation. Solve them in free space. [12 pts.]

ii. Consider the potential function $V = -\alpha xy$, where α is a constant. Obtain the value of the electric field. [08 pts.]

iii. What is the fundamental source of electromagnetic radiation? [05 pts.]

Contd.

(2) (a) Consider the following standing waves:

$$E = E_m(\sin \omega t)(\sin kx)$$
$$B = B_m(\cos \omega t)(\cos kx)$$

i. Show that these satisfy $\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t}$ and $\frac{\partial B}{\partial x} = -\mu_0 \varepsilon_0 \frac{\partial E}{\partial t} = \frac{1}{c^2}\frac{\partial E}{\partial t}$ if E_m is suitably related to B_m and ω suitably related to k. What are these relationships? [12 pts.]

ii. Find the instantaneous Poynting vector. [10 pts.]

iii. Show that the time average power flow across any area is zero. You may use $\int_0^T \sin^2 \omega t \, d \sin \omega t = 0$. [08 pts.]

iv. Describe the flow of energy in this problem. [10 pts.]

(b) Do Maxwell's equations prescribe any change in the velocity of electromagnetic waves through free space or any restriction to the frequency of oscillations in these waves? Justify your answer. [10 pts.]

(3) (a) i. Describe the behavior of a series RLC circuit for the cases $\chi_C > \chi_L$ and $\chi_C < \chi_L$. [10 pts.]

ii. Discuss the phenomenon of resonance in series RLC circuit. [10 pts.]

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 inductances are far apart. [15 pts.]

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

ii. Prove that the voltage magnification of a RLC circuit is equal to its Q at resonance. [10 pts.]

End.