RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year - Semester I Examination – October/November 2015

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) 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 and the curl of the gradient of a scalar Φ is zero. [16 marks]

(ii) What do you conclude from the above relations? How is the idea of vector potential introduced? [12 marks]

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

ii. If $\vec{A} = x^2 s\hat{i} - 2y^3 s^2 \hat{j} + xy^2 s\hat{k}$; calculate div $\vec{A}$ at the point (1,-1,1). [10 marks]

Contd.

(2) (a) (i) Describe the Physical significance of the Poynting vector. [06 marks]

(ii) Calculate the Poynting vector for a long straight wire of resistance R, radius a and length l, which carries a constant current I along the wire. Recall that the magnetic field at the surface of the wire is given by $B=\mu_0 I/2\pi a$. [16 marks]

(iii) Hence, show that the rate at which electromagnetic energy flows into the wire equals the rate of energy dissipated as joule heat. [08 marks]

(b) (i) 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 marks]

(ii) "*Plane electromagnetic waves follow the laws of reflection just like light radiations*". State whether the above statement is true or false. Explain. [10 marks]

(3) (a) (i) Discuss the phenomenon of resonance in series RLC circuit. [10 marks]

(ii)The average power delivered to a series RLC circuit at frequency ω is given by $P_{av} = \frac{V_{rms}^2 R\omega^2}{R^2\omega^2 + L^2(\omega^2 - \omega_0^2)^2}$. Show that the peak current can be written as $I_0 = \omega V_0[L^2(\omega_0^2 - \omega^2)^2 + (\omega R)^2]^{-1/2}$, where ω is the operating frequency of the circuit and ω_0 is the resonance frequency. Also show that the phase angle can be expressed as $\phi = \tan^{-1}\left[\frac{L}{R}\left(\frac{\omega_0^2 - \omega^2}{\omega}\right)\right]$. [14 marks]

(b) (i) What is it meant by the Quality factor (Q) of a circuit? [06 marks]

(ii) Explain how the quality factor is related to the response characteristics of a receiver. Which variable most strongly determines the quality factor? [10 marks]

(iii) "*At frequencies above resonant frequency, impedance is inductive*" State whether the above statement is true or false. Explain [10 marks]

End.