B.Sc. 6th Semester (Honours) Internal Examination, 2019-20

PHYSICS

Course ID: **Course Code: SH/PHS/601/C/13**

Course Title: Electromagnetic Theory

Time: 1Hour 15 Minutes Full Marks: 20

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words
As far as practicable

1. Choose the correct alternatives from any **five** from the followings: $1\times5=5$

(i) For a good conductor, Electric field leads Magnetic field by : (a) 45° (b) -45° (c) 90° (d) -90°

(ii) Unit of Magnetic flux is : (a) Vm (b) Wb (c) Fm^2 (d) V/m

(iii) The equation containing the fact of non-existence of magnetic monopole is: (a) $\vec{\nabla}\cdot\vec{B}=0$ (b) $\vec{\nabla}\times\vec{B}=0$ (c) $\nabla^2\vec{B}=0$ (d) none

(iv) For steady current region: (a) $\vec{\nabla}\cdot\vec{j}=0$ (b) $\vec{\nabla}\times\vec{j}=1$ (c) $\vec{\nabla}\cdot\vec{j}\neq0$ (d) $\vec{\nabla}\cdot\vec{j}=1$

(v) For lossless dielectric: (a) $\sigma>>\omega\varepsilon$ (b) $\sigma<<\omega\varepsilon$ (c) $\sigma\sim\omega\varepsilon$ (d) $\sigma=\omega\varepsilon$

(vi) Velocity of an EM wave is: (a) $1/\sqrt{\mu\varepsilon}$ (b) $\sqrt{\mu\varepsilon}$ (c) $2/\sqrt{\mu\varepsilon}$ (d) $1/\sqrt{2\mu\varepsilon}$

(vii) Unit of Poynting vector may be: (a) W/ m^2 (b) Wb (c) Fm^2 (d) J/m

2. Answer any **one** question: $5\times1=5$

(a) Explain the inconsistency of Ampere's law and discuss necessary Maxwell's modification. [5]

(b) Write down Maxwell's equations and mention the significance of each mentioning inherent laws. [5]

(c) State Faraday's law of Electromagnetic Induction and Show that $\vec{\nabla}\times\vec{E}=-\partial\vec{B}/\partial t$ [5]

(d) Calculate (i) Skin depth, (ii) wave velocity at a frequency of 1.6MHz in aluminium, where $\sigma=38.2MS/m$ and $\mu_r=1$. [5]

(e) Find the conduction and the displacement current density in a medium having conductivity of 10^{-3}S/m and $\varepsilon_r=2.5$ if

$E=0.5\times10^{-6}\sin(9\times10^9)t$ V/m [5]

3. Answer any **one** question: $10\times1=10$

(a) Show that In time varying EM field, under Lorentz-gauge condition $\vec{\nabla}\cdot\vec{A}=-\mu\varepsilon(\partial V/\partial t)$.

(i) $\vec{E}=-\vec{\nabla}V-\partial\vec{A}/\partial t$ (ii) $\nabla^2V-\mu\varepsilon(\partial^2V/\partial t^2)=-\rho/\varepsilon$ (iii) $\nabla^2\vec{A}-\mu\varepsilon(\partial^2\vec{A}/\partial t^2)=-\mu\vec{j}$, where symbols have their usual meanings. [10]

(b) Derive wave equation for electric field from Maxwell's equations. Identify the complex propagation constant and its components. For conducting media, find the expression for skin depth. (use conventional symbols for angular frequency, permeability and permittivity) [10]

(c) (i) Assuming that electric field is of the form $\vec{E}=E_0e^{-\alpha z}\cos(\omega t-\beta z)\hat{i}$, Find vector magnetic field and expression for intrinsic impedance of a medium. Show that intrinsic impedance of free space is ~377 ohm.

(ii) Find Intricsic impedance of a conductor. [7+3]

(d) Derive Poynting Theorem. Identify the Poynting vector. What is the significance of Poynting vector? Deduce an expression for (i) instantaneous and (ii) average Poynting vector. [10]

(e) Show that the reflection coefficient and transmission coefficient for normal incidence can be expressed as:

$$\Gamma=\frac{\eta_2-\eta_1}{\eta_2+\eta_1} \text{ and } \tau=\frac{2\eta_2}{\eta_2+\eta_1} \text{ respectively.}$$

Calculate the reflection coefficient and transmission coefficient for the interface of two nonmagnetic good dielectrics of permittivity ϵ_1 and ϵ_2. [10]

(f) Show that refractive index (n) of a dielectric can be expressed as: $n=\sqrt{\varepsilon_r}$ considering $\mu_r=1$. Hence show that refractive index of a medium (1)with respect to another medium(2) = η_1/η_2. Also show that refractive index of a conducting medium: $n=(1-j)\sqrt{\sigma/2\omega\varepsilon_0}$