Code : 102101

B.Tech 1st Semester Exam., 2018 (New)

PHYSICS

(Electromagnetism)

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Answer any *seven* of the following questions : 2×7=14

(a) Differentiate between conduction and convection current.

(b) The electric flux density is given as $20/r\hat{a}_r$. Calculate the total charge in the region defined by $0 \le r \le 5$.

(c) What do you mean by magnetic torque and magnetic dipole moment?

(d) An infinite sheet in xy-plane extending from $-\infty$ to ∞ in both directions has a uniform charge density of $5\ nC/m^2$. Find the electric field at $z = 10$ cm.

(e) What do you mean by skin effect?

(f) Differentiate between linear, elliptical and circular polarization.

(g) With necessary expression, explain standing wave ratio.

(h) Determine the skin depth of copper at 100 MHz. Assume $\sigma = \frac{58\,MS}{m}$ and $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m.

(i) Explain the terms 'motional e.m.f.' and 'transformer e.m.f.'

(j) What is meant by retarded potential?

2. Answer any *two* of the following questions : 7×2=14

(a) An EM wave propagating in free space is described by the equation

$$E = E_0 \cos(\omega t - kz)a_x - E_0 \sin(\omega t - kz)a_y$$

Determine *(i)* polarization of the wave and *(ii)* magnetic field and the Poynting vector.

(b) Show that Cartesian components of E and H satisfy the three-dimensional wave equation using Maxwell's equations in a dielectric.

(c) The magnetic field for an x-polarized plane wave propagating in a dielectric of refractive index 1·5 along the z-direction is given by $H = 0 \cdot 04 \sin(10^{15} t - kz)$ A/m. Calculate the values of wavelength, frequency, Poynting vector and also write the expression for electric field.

3. Answer any *two* of the following questions : 7×2=14

(a) Derive the boundary conditions for electrostatic field intensity and electric flux density at *(i)* the interface between two dielectrics and *(ii)* the interface between a perfect conductor and a dielectric.

(b) A long spherical cloud of radius r has a uniform volume charge distribution of ρ_v. Calculate the potential distribution and the electric field at any point in space using Poisson's and Laplace's equation.

(c) A coaxial cable has two concentric cylinders of radii a and b $(a < b)$. The space between the two conductors is filled with dielectric of permittivity ε for $a < r < b$. If the inner cylinder is held at potential V_0 with respect to the outer sphere, determine electric field intensity and potential in the two regions.

4. Answer any *two* of the following questions : 7×2=14

(a) Write an explain Maxwell's equations for a linear, homogeneous medium in terms of E_s and H_s and also write the Maxwell's equation in a source-free region.

(b) An EM wave in a lossless medium impinges normally on a lossy medium. *(i)* Determine the ratio of transmitted to incident power. *(ii)* Express the ratio of reflected to incident power.

(c) In a nonmagnetic medium $E = 4 \sin(2\pi \times 10^7 t - 0 \cdot 8x) a_z$ V/m. Find *(i)* ε_r and intrinsic impedance, *(ii)* the time average power carried by the wave and *(iii)* total power crossing 100 cm^2 of plane $2x + y = 5$.

5. Answer any *two* of the following questions : 7×2=14

(a) *(i)* State Ampere's circuit law.

(ii) A hollow conducting cylinder has inner radius a and outer radius b and carries current I along the positive z-direction. Find H everywhere.

(b) A circular loop located on $x^2 + y^2 = 9$, $z = 0$ carries a direct current of 10 A along a_ϕ. Determine H at (0, 0, 4) and (0, 0, −4).

(c) Determine the gradient and also find the Laplacian of the scalar fields given below :

(i) $V = e^{-z} \sin 2x \cosh y$

(ii) $U = \rho^2 z \cos 2\phi$

(iii) $w = 10 r \sin^2 \theta \cos \phi$

6. Answer any *two* of the following questions : 7×2=14

(a) The *xy*-plane serves as the interface between two different media. Medium 1($Z < 0$) is filled with a material whose $\mu_r = 6$ and medium 2($Z > 0$) is filled with a material whose $\mu_r = 4$. If the interface carries current $(1/\mu_0) a_y$ mA/m, and $B_2 = 5a_x + 8a_z m$ Wb/m^2, find H_1 and B_1.

(b) For a linear, isotropic and homogeneous magnetic medium, show that

$$M = \frac{\chi m}{\mu_0 (1 + \chi m)} B$$

(c) Determine the self-inductance of a coaxial cable of inner radius *a* and outer radius *b*.

7. Answer any *two* of the following questions : 7×2=14

(a) A parallel-plate capacitor with plate area 5 cm^2 and plate separation of 3 mm has a voltage $50 \sin 10^3 t$ volt applied to its plates. Calculate the displacement current assuming $\varepsilon = 2\varepsilon_0$.

(b) In a lossless dielectric for which $\eta = 60\pi$, $\mu_r = 1$ and $H = -0.1 \cos(\omega t - z) a_x + 0.5 \sin(\omega t - z) a_y$ A/m, calculate ε_r, ω and E.

(c) A uniform plane wave propagating in a medium has $E = 2e^{-\alpha z} \sin(10^8 t - \beta z) a_z$ V/m. If the medium is characterized by $\varepsilon_1 = 1$, $\mu_r = 20$ and $\sigma = 3$ S/m, find α, β and H.

8. Answer any *two* of the following questions : 7×2=14

(a) Determine the polarization of the wave with—

(i) $E(z, t) = 4e^{0.25z} \cos(\omega t - 0.8z) a_x + 3e^{0.25z} \sin(\omega t - 0.8z) a_z$ V/m;

(ii) $H(z) = H_0 e^{-j\beta z} a_x - 2H_0 e^{-j\beta z} a_y$.

(b) A uniform plane EM wave with field varying sinusoidally in medium is incident normally on the surface of medium. Derive the expression for the reflection and refraction coefficients.

(c) Obtain Poynting theorem for conservation of energy in an EM field and discuss the physical significance of each terms in resulting equation.

9. Answer any *two* of the following questions : 7×2=14

(a) A 10 cm long current element is located at origin in free space carrying a current of 100 mA along x-direction. Find the force on the current filament if a filamentary current of $12a_z$ A is located along $x=3$ and $y=4$.

(b) The electric field intensity in polystyrene ($\varepsilon_r = 2 \cdot 55$) filling the space between parallel plate capacitors is 10 kV/m. The distance between the plates is 1·5 mm. Calculate *(i)* the surface charge density on the plates and *(ii)* the potential difference between the plates.

(c) Determine whether the following potential equations satisfy Laplace's equation or not :

(i) $V = 2x^2 - 4y^2 + z^2$

(ii) $V = r^2 \cos\phi + \theta$

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