

Code : 102101

(2)

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 $0 \leq r \leq 5$.
- (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 $z = 10 \text{ cm}$.

- (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 $\sigma = \frac{58 \text{ MS}}{m}$ and $\mu = \mu_0 = 4\pi \times 10^{-7} \text{ H/m}$.
- (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

$$E = E_0 \cos(\omega t - kz)\hat{a}_x - E_0 \sin(\omega t - kz)\hat{a}_y$$
 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 $H = 0.04 \sin(10^{15}t - kz)$ 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 and 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 $E = 4 \sin(2\pi \times 10^7 t - 0.8x) a_z$ 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) $w = 10r \sin^2 \theta \cos \phi$
6. Answer any two of the following questions :
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- (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 $B_2 = 5a_x + 8a_z$ mWb/m², 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 $50 \sin 10^8 t$ volt applied to its plates. Calculate the displacement current assuming $\epsilon = 2\epsilon_0$.
- (b) In a lossless dielectric for which $\eta = 60\pi$, $\mu_r = 1$ and $H = -0.1 \cos(\omega t - z a_z + 0.5 \sin(\omega t - z a_y)$ 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 $\epsilon_1 = 1$, $\mu_r = 20$ and $\sigma = 3 \text{ S/m}$, 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) $E(z, t) = 4e^{0.25z} \cos(\omega t - 0.8z a_z) + 3e^{0.25z} \sin(\omega t - 0.8z a_z)$ 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 ($\epsilon_r = 2.55$) 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) $V = r^2 \cos\phi + \theta$
