Total No. of printed pages = 4

EE 181603

Roll No. of candidate

2022

B.Tech. 6th Semester End-Term Examination

ELECTROMAGNETIC FIELD THEORY

(New Regulations & New Syllabus)

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any *four* from the rest.

1. Answer the following : (10 × 1 = 10)

(i) At cartesian point (–3, 4, –1) which of these is incorrect?

(a) $\rho = \frac{-5}{\sqrt{26}}$ (b) $r = \sqrt{26}$

(c) $\theta = \tan^{-1}\frac{5}{-1}$ (d) $\phi = \tan^{-1}\frac{4}{-3}$

(ii) If a vector field Q is solenoidal, which of these is true?

(a) $\oint_L Q.dl = 0$ (b) $\oint_S Q.ds = 0$

(c) $\nabla \times Q = 0$ (d) $\nabla \times Q \neq 0$

(iii) An electric potential field is produces at point charges 1 μC and 4 μC located at (–2,1,5) and (1,3 –1) respectively. The energy stored in the field is

(a) 2.47mJ (b) 5.14mJ

(c) 10.28 mJ (d) 0.73 mJ

(iv) In free space, the Poisson equation becomes

(a) Maxwell equation (b) Ampere equation

(c) Laplace equation (d) Steady state equation

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(v) The electric field of a potential function given by (20 log $x + y$) at the Point (1,1,0).

(a) $-20a_x - a_y$ (b) $-ax - 20a_y$

(c) $a_x + a_y$ (d) $(a_x + a_y)/20$

(vi) Using Maxwell equation which of the following cannot be calculated directly?

(a) Magnetic field density B (b) Electric field density D

(c) Magnetic vector potential A (d) Magnetic Field intensity H

(vii) In a certain medium $E = 10\cos(10^8 t - 3y)a_x V/m$. What type of medium is it?

(a) Free space (b) Lossless dielectric

(c) Lossy dielectric (d) Perfect conductor

(viii) Earth receives 1400 J/s/m2 of solar energy. What is the value of lilt?

(a) 1.98 A/m (b) 2.45 A/m

(c) 3.75 A/m (d) 4.13 A/m

(ix) When does wave propagating from One medium to another gets Partially reflected and Partially transmuted?

(a) Both mediums have same electrical properties

(b) Both mediums have different electrical properties

(c) Both mediums have same magnetic properties

(d) Both mediums have different magnetic properties

(x) The relation between the skin depth and frequency is given by

(a) Skin depth α f (b) Skin depth α 1/f

(c) Skin depth α $\sqrt{f}$ (d) Skin depth α $1/\sqrt{f}$

2. (a) Transform the vector $A = xy^2za_x + x^2yza_y + xyz^2a_z$ into cylindrical coordinates (4)

(b) Find the constants a,b,c so that the vector A is irrotational. Where $A = (x + 2y + az)a_x + (bx - 3y - z)a_y + (4x + cy + 2z)a_z$. (4)

(c) Derive the expression for the divergence of a vector field in Cartesian coordinate system from its principle. (7)

3. (a) Derive the expression for the energy present in an assembly of charges. Evaluate the value of stored energy in a system of four identical charges Q = 2nC at the corners 1m on a side. (5)

(b) Discuss the boundary relations at the boundary of two dielectrics in terms of tangential and normal component of E and D. (4)

(c) (i) Evaluate the potential, electric field strength and surface charge density due to a point charge above a grounded conducting plane using the method of images. (6)

Or

(ii) Prove that the solution to the Poisson's and Laplace's equation which satisfies the same CC boundary conditions must be a unique solution. (6)

4. (a) Derive the expression for the magnetic field intensity at a point P due to an infinite straight current conductor. (6)

(b) State and explain Amperes Law as used in magnetic fields. Derive the expression for the modified Ampere's law. (5)

(c) A circular conductor of radius $r_0 = 1\,\text{cm}$ has internal field (4)

$$H = \frac{10^4}{r}\left[\frac{1}{a^2}\sin ar - \frac{r}{a}\cos ar\right] a_\phi A/m$$

Where $a = \frac{\pi}{2r_0}$. Find the total current in the conductor.

5. (a) Starting with Maxwell's equation, derive the wave equation for E in a perfect dielectric. (7)

(b) A conductor has the following properties: σ = 35 Ms/m, ε_r = 1 carries a current $i_c = 2.5\cos(5\times10^8 t)\mu A$. Calculate the loss tangent. (4)

(c) A uniform plane wave in a medium having $\sigma = 2.5 \times 10^{-3}$ S/m, $\varepsilon_r = 25$ and $\mu_r = 1$ is having a frequency of 180 MHz. Calculate attenuation constant, phase constant, intrinsic impedance, propagation constant, wavelength, skin depth and phase velocity of the wave. (4)

6. (a) State Poynting Theorem and derive the expression for the same. (7)

In free space, $E(x,t) = 50\cos(\omega t - \beta x)a_y$ V/m. Find the average power crossing a circular area of radius 5 m in the plane x = constant.

(b) Derive the expression for the reflection and transmission coefficients of a uniform plane wave by perfect dielectric for normal incidence. (4)

(c) Calculate the skin depth, propagation constant and wave velocity at frequency of 1.6 MHz in aluminium where σ =3. 8.2 MS/m and $\mu_r = 1$. (4)

7. Answer any *three* : (3 × 5 = 15)

(a) What are Scalar and Vector Potential? Find the expressions for the same.

(b) Derive Laplace's equation. If $\varepsilon = \varepsilon_0$ and $V = 8x^2yz$ and $P(2,-1,3)$, find V, ρ_v at P. Does V satisfy Laplace's equation.

(c) Given $A = \frac{10\rho^3}{4}a_\rho$ in cylindrical system. Verify divergence theorem for the volume enclosed by $\rho = 2, z = 0$ to 10

(d) From the concepts of Time —Varying Potentials, develop the wave equations and hence the expression for the retarded electric scalar potential and the retarded magnetic vector potential.

(e) Develop an expression for electric field intensity at a general point P due to a semi-infinite straight line charge with charge density ρ_l C/m.