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Total Number of Pages: 02

B.Tech.
PEE3I001

3rd Semester Regular / Back Examination 2017-18

ELECTROMAGNETIC THEORY

BRANCH: ELECTRICAL

Time: 3 Hours

Max Marks: 100

Q.CODE: B1115

Answer Question No.1 and 2 which are compulsory and any four from the rest.
The figures in the right hand margin indicate marks.

Q1 Answer the following questions: *multiple type or dash fill up type* (2 x 10)

- Where surfaces $\rho=2$ and $z=1$ intersect is i) an infinite plane ii) a semi-infinite plane iii) a circle iv) a cylinder v) a cone.
- The curl of the gradient of a scalar field defined by $V = 2x^2y + 3y^2z + 4z^2x$ is ____.
- The flux density at a given point in space is given by $\mathbf{B} = 4x\mathbf{a}_x + 2ky\mathbf{a}_y + 8z\mathbf{a}_z$ Wb/m². The value of k is ____.
- The divergence of curl of a vector is ____.
- If in free space, the electric field is given by $\mathbf{E} = 20 \cos(\omega t - 50x)\mathbf{a}_y$ V/m the displacement current density is ____.
- An electric potential field is produced by point charge 1 μC and 4 μC located at (-2,1,5) and (1,3,-1) respectively. The energy stored in the field is ____.
- The unit of magnetic charge is ____.
- The flux through each turn of a 100 turn coil is $(t^3 - 2t)$ mWb, where t is in seconds. The induced emf at t=2 s is ____.
- The skin depth of Copper at 50 Hz is ____ given $\sigma=5.8 \times 10^7$ S/m and $\mu=\mu_0$.
- Microwaves have a frequency range of approximately ____.

Q2 Answer the following questions: *Short answer type* (2 x 10)

- In what aspects field theory is superior to circuit theory in understanding electromagnetics?
- What do you understand by harmonic and solenoidal fields?
- Convert points P(1,3,5) from Cartesian to cylindrical coordinates.
- What are the constraints in application of Gauss's Law?
- State the significance of uniqueness theorem.
- State Ampere's circuit law and derive the third of Maxwell's equations from it.
- What do you understand by relaxation time?
- Define attenuation constant and phase constant of a medium.
- Write two application of method of images.
- What is intrinsic impedance of a medium?

Q3 a) Describe in details the various coordinate systems used in Electromagnetics. (10)

b) Evaluate both sides of the Stoke's theorem for the field (5)

$$\mathbf{F} = 3y^2z \mathbf{a}_x + 6x^2z \mathbf{a}_y + 9xz^2 \mathbf{a}_z.$$

- Q4** a) Derive the expression of electric field due to a line charge using both Coulomb's Law and Gauss's law. (10)
- b) Given that $\mathbf{E} = (3x^2 + y)\mathbf{a}_x + x\mathbf{a}_y$ kV/m, find the work done in moving a $-2 \mu\text{C}$ charge from $(0, 5, 0)$ to $(2, -1, 0)$ by taking a straight line path $(0, 5, 0) \rightarrow (2, 5, 0) \rightarrow (2, -1, 0)$. (5)
- Q5** a) Explain various aspects of polarization in dielectrics. Derive the expression for dielectric constant and electric susceptibility. (10)
- b) A homogeneous dielectric ($\epsilon_r = 2.5$) fills region 1 ($x < 0$) while region 2 ($x > 0$) is free space. If $\mathbf{D}_1 = 12\mathbf{a}_x - 10\mathbf{a}_y + 4\mathbf{a}_z$ nC/m², find \mathbf{D}_2 . Also, if $E_2 = 12$ V/m find E_1 . (5)
- Q6** a) Describe the various aspects of magnetization in materials. (10)
- b) A current distribution gives rise to the vector magnetic potential $\mathbf{A} = x^2 y \mathbf{a}_x + y^2 x \mathbf{a}_y - 4xyz \mathbf{a}_z$ Wb/m². Calculate the flux through the surface defined by $z=1$, $0 \leq x \leq 1$ and $-1 \leq y \leq 4$. (5)
- Q7** a) Explain Faraday's law describing in detail transformer and motional electromotive forces under all the three conditions. (10)
- b) A conducting circular loop of radius 20 cm lies in the $z=0$ plane in a magnetic field $\mathbf{B} = 10 \cos 377t \mathbf{a}_z$ mWb/m². Calculate the induced voltage in the loop. (5)
- Q8** a) A plane wave propagating through a medium with $\epsilon_r = 8$, $\mu_r = 2$ has $\mathbf{E} = 0.5 \exp(-z/3) \sin(10^8 t - \beta z) \mathbf{a}_x$ V/m. Determine:
i) β ,
ii) wave velocity,
iii) loss tangent,
iv) H field
v) intrinsic impedance. (10)
- b) State Maxwell's equations in differential and integral forms. (5)
- Q9** a) Derive Poynting theorem and find the expression for time average power crossing a given surface S in terms of Poynting vector. (10)
- b) Given that in air, $\mathbf{H} = 0.1 \sin(\pi \times 10^8 t + \beta y) \mathbf{a}_x$ A/m, find the time average power density in the wavefront. (5)