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Question Paper Code : 50963

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Fourth Semester

Electronics and Communication Engineering

EC 3452 – ELECTROMAGNETIC FIELDS

(Common to Electronics and Telecommunication Engineering)

(Regulations 2021)

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

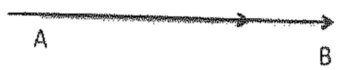
1. Transform the vector $\vec{Q} = \frac{\sqrt{x^2+y^2}}{\sqrt{x^2+y^2+z^2}}\vec{a}_x - \frac{yz}{\sqrt{x^2+y^2+z^2}}\vec{a}_z$ to cylindrical and spherical coordinates.

2. Define the divergence theorem and stokes theorem.

3. Two point charges with $q_1 = 2\times10^{-5}$ and $q_2 = -4x\times10^{-5}C$ are located in free space at $(1, 3, -1)$ and $(-3, 1, -2)$ respectively, in a Cartesian Coordinate system. Find the electric field $\vec{E}$ at $(3, 1, -2)$ and the force of an $8\times10^{-5}C$ charge located at that point. All distances are in metres.

4. Justify the statement, "Total electrostatic field of any closed loop is zero".

5. Predict the direction of the magnetic field, when current is passing from point A to B (y direction).



6. A current loop experiences a torque in a magnetic field. Justify that the force exerted on the whole loop is zero.

7. Recall the four Maxwell equations for time-varying fields.

8. How to overcome the inconsistency of Ampere's law in the time-varying field?

9. Rearrange the Poynting vector, when the wave is propagated through a pure dielectric medium.

10. A plane wave propagating through a dielectric medium with $\varepsilon_r = 8$, $\mu_r = 2$ and $E = 0.5e^{-z/3}\sin(10^8 t - \beta z)a_y\, V/m$. Find the phase constant and skin depth.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Analyze the Gradient of scalar and divergence and curl of the vector. (6)

(ii) Find the gradient of the scalar fields $U = x^2y + xyz$ and $U = e^{-z}\sin 2x\cos y$. (7)

Or

(b) (i) Convert points $P(1, 3, 5)$ and $T(0, -4, 3)$ from Cartesian to cylindrical and Spherical coordinates. (6)

(ii) Compute the divergence and curl of the vector field $A = yz\vec{a}_x + 4xy\vec{a}_y + y\vec{a}_z$ and evaluate it at the point $(1, -2, 3)$. (7)

12. (a) (i) If $D = (2y^2 + z)\vec{a}_x + 4xy\vec{a}_y + x\vec{a}_z\, C/m^2$, find (7)

(1) The volume charge density is at $(-1, 0, 3)$.

(2) The flux through the cube is defined by $0 \le x \le 1, 0 \le y \le 1, 0 \le z \le 1$.

(3) The cube encloses the total charge.

(ii) Rearrange Gauss's law and develop Laplace's and Poisson's equations. (6)

Or

(b) (i) Interpret the Electric Flux density for a uniformly charged sphere of radius 'a'. Construct a Gaussian surface for the case of $r \ge a$ and $r \le a$ separately. (6)

(ii) A parallel-plate capacitor has a plate area of 200 m^2 and a plate separation of 3 cm. The charge density is with air dielectric. Determine

(1) The capacitance of the capacitor. (4)

(2) The voltage between the plates (3)

13. (a) Prove that total magnetic field intensity (H) outside of the outer coaxial conductor is zero for infinitely long coaxial transmission line using Amperes law. Determine H at each Amperian path.

Or

(b) Determine the Magnetic field and current distributions for the following three conditions

(i) Infinite line current along the z-axis (4)

(ii) Infinite sheet of current (4)

(iii) Infinitely long coaxial transmission line (5)

14. (a) (i) A thin ring of radius 5 cm is placed on plane $z = 1$ cm so that its center is at $(0, 0, 1)$cm. If the ring carries 50 mA $\vec{a}_\phi$, find H at $(0, 0, -1)$cm and $(0, 0, 10)$cm. (7)

(ii) Prove that Maxwell's equations are related to time-varying magnetic fields. (6)

Or

(b) (i) Reconstruct Ampere's circuit law for time-varying situations to satisfy Faraday's law. (7)

(ii) Derive the Helmholtz's wave equations for both E and H fields. (6)

15. (a) Conclude that the tangential components of $\vec{H}$ are discontinuous across the boundary, and the normal components of $\vec{H}$ are continuous across the dielectric-dielectric boundary medium. Besides, determine $\vec{H}$'s tangential and normal components across the dielectric-conductor boundary medium.

Or

(b) (i) A uniform plane wave propagating in a lossless medium has $\vec{E} = 2\sin\left[10^8 t - \beta z\right]\vec{a}_y V/m$. If $\varepsilon_r = 1$, $\mu_r = 2$ and $\sigma = -3V/m$, characterize the medium. Compute the $\eta\beta$ and H. (7)

(ii) If the wave encounters a perfectly conducting plate normal to the z-axis at $z = 0$, find the reflected wave E_r and H_r. (6)

PART C — (1 × 15 = 15 marks)

16. (a) Develop the transmission and reflection coefficient expression when the incident wave from medium 2 propagates to medium 1 in normal incidence. Assume Medium 2 is air and medium 1 is Polyethline with $\varepsilon_r = 2.25$; $\mu_r = 1$. (15)

Or

(b) Discuss the variation of flux with time in the following three ways :

(i) A stationary loop in a time-varying magnetic field (Transformer emf) (5)

(ii) A time-varying loop in a static magnetic field(Motional emf) (5)

(iii) A time-varying loop in a time-varying magnetic field (5)