Reg No.:_______________ Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree Supplementary Examination June 2023 (2019 scheme)

Course Code: EET204

Course Name: ELECTROMAGNETIC THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1 Explain the physical meaning of the divergence of a vector field. (3)

2 Given the vector field $\vec{A}=x^2\hat{z}$ where $\hat{z}$ denotes the unit vector along the z-axis in a right-handed Cartesian co-ordinate system. Compute $\vec{\nabla}\times\vec{A}$. (3)

3 State Coulombs law and use it to represent the vector forces $\vec{F}_1$ and $\vec{F}_2$ acting on two point charges q_1 and q_2 respectively, separated by a distance r in free space. (3)

4 Define electric field intensity and electric potential. (3)

5 Explain the terms self-inductance and mutual inductance (3)

6 State Amperes circuital law and express it in integral and vector forms (3)

7 Define the term intrinsic impedance. (3)

8 Define the term skin depth. (3)

9 Explain impedance matching. (3)

10 What are the various transmission line parameters? (3)

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) State Stokes Theorem. (4)

b) Consider a vector field represented in a right-handed Cartesian coordinate system as $\vec{f} = xy\,\hat{x} + yz\,\hat{y}$ where $\hat{x}$ and $\hat{y}$ represent the unit vectors along the x and y directions respectively. Compute $\vec{\nabla}.\vec{f}$ and verify the divergence theorem for the unit cubical volume shown in Fig.1. (10)

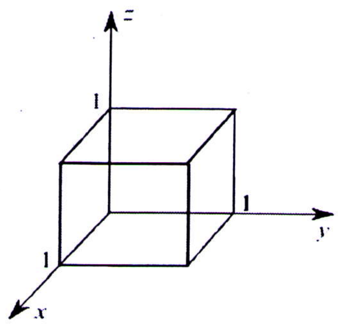

Fig. 1

12 a) Derive the matrix which transforms the vector $\vec{A} = A_x\,\hat{x} + A_y\,\hat{y} + A_z\,\hat{z}$ expressed in the Cartesian co-ordinates, to $\vec{A} = A_\rho\,\hat{\rho} + A_\phi\,\hat{\phi} + A_z\,\hat{z}$ as expressed in cylindrical co-ordinates. (6)

b) Using spherical co-ordinates, show that the volume V of a sphere of radius R is given as $V = \frac{4}{3}\,\pi\,R^3$ (8)

Module -2

13 a) Explain Poisson's and Laplace's equations. (4)

b) A circular disc of radius 'a' m is charged uniformly with a charge density of 'σ' Coulombs/ m2 lying in the *xy*-plane and centred at the origin of the coordinate system. Find the electric field at a point on the *z*-axis at a distance *h* above the plane (10)

14 a)

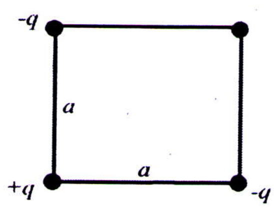

Fig. 2 (7)

Three charges are located at the corners of a square of side *a*, as shown in Fig.2. Calculate the work done in bringing another charge +*q*, from a far-away point and placing it at the fourth corner.

b) Using Gauss's law, derive an expression for the electric field intensity due to an infinite line charge with charge density λ Coulombs per meter. (7)

Module -3

15 a) A circular loop of wire lying in the *xy*-plane and centred at the origin of the coordinate system is carrying a current *I*. Using Biot and Savart's law calculate the magnetic flux density at a point on the *z*-axis at a distance *h* above the plane of the loop. (7)

b) Derive the boundary conditions that must be obeyed by static $\vec{H}$ *and* $\vec{B}$ fields at the interface of two different materials of permeability μ_1 *and* μ_2. (7)

16 a) Explain the formulation of the magnetic vector potential $\vec{A}$. Why is $\vec{\nabla}.\vec{A}$ chosen as equal to zero?. (7)

b) Using Biot-Savart's law, derive an expression for the magnetic flux density due to an infinitely long current carrying conductor in free space lying along the z-axis. Use the result to calculate the force per unit length between two infinitely long conductors carrying a current of *1A* each in the z-direction separated by a distance of *1m*. (7)

Module -4

17 a) State and prove Poynting's theorem. Explain the physical significance of the Poynting vector. (7)

b) The electric field inside a non-magnetic medium is given as: (7)

$$\vec{E} = 50\cos(8x - 10^9 t)\,\hat{y} - 40\sin(8x - 10^9 t)\,\hat{z}\ V/m$$

Calculate the corresponding $\vec{H}$ field.

18 a) Starting from the Maxwell's equations, show that empty space can support the propagation of electromagnetic waves, and calculate the speed of these waves. (7)

b) Derive the expression for the attenuation constant and phase constant for a uniform plane wave in a good conductor (7)

Module -5

19 a) What are the conditions required for a distortion less transmission line. Derive the phase velocity of such a line and explain its benefits. (6)

b) Derive the expression for the input impedance and the voltage reflection coefficient for a lossless transmission line of characteristic impedance Z_0 terminated with load impedance Z_L. (8)

20 a) A lossless line operating at 100 MHz has a characteristic impedance $Z_0 = 70\ \Omega$ and phase constant of $3\ rad/m$. Calculate the inductance per meter and capacitance per meter for the line. (6)

b) Derive the equation representing the propagation of a voltage wave on a transmission line. (8)

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