4E2088

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B.Tech. (Sem. IV) (Main / Back) Examination, June / July - 2011
4EC4 Electromagnetic Field Theory
(Common for Electronics & Comm. Engg. and EI & C Engg. Branch

Time : **3** Hours] [Total Marks : **80**
[Min. Passing Marks : **24**

Attempt overall Five questions selecting one question from each unit. All questions carry equal marks. (Schematic diagrams must be shown wherever necessary. And data you feel missing may suitably be assumed and stated clearly. Units of quantities used/ calculated must be stated clearly.)

Use of following supporting material is permitted during examination.
(Mentioned in form No. 205)

1. Calculator 2. Nil

UNIT - I

1 (a) Define Curl of a vector field. **2**

(b) A vector is given in Cartesian coordinates as $\vec{A} = xy\,\hat{a}_x - 2y\hat{a}_y$

Express $\vec{\nabla} \times \vec{A}$ in cylindrical and spherical coordinates. **3+3**

(c) Give the physical interpretation of curl of a vector field. **8**

OR

1 (a) A vector in cylindrical coordinates is given as

$\vec{A} = 2\cos\phi\,\hat{a}_\rho + \rho\hat{a}_\theta$

verify Stoke's theorem for the surface bounded $by + x\ axis, +y$ axis and arc of the circle of radius 1 unit with centre at the origin. **8**

(b) Assume a scalar field $T = x^2 + 3yz + 4xy^2$. Determine $\vec{\nabla}T$.

Show that $\int_a^b \vec{\nabla}T \, \vec{dl}$ is independent of path. Assume $a = (0, 0, 0)$, $b = (2, 2, 2)$ and use (i) the straight line path $p(0, 0, 0) \to (2, 0, 0) \to (2, 2, 0) \to (2, 2, 2)$ and (ii) the straight line path from a to b.

2+6

UNIT - II

2 (a) State Gauss's law of electrostatics for the electric field intensity $\vec{E}$.

2

(b) Obtain the differential form of Gauss's law from its integral form.

3

(c) Electric flux density $\vec{D} = 6xyz^2\hat{a}_x + 3x^2z^2\hat{a}_y + 6x^2yz\,\hat{a}_z\, C/m^2$. Find the total charge lying within the region bounded by $1 \le x \le 3m, 0 \le y \le 1m$ and $-1 \le z \le 1m$.

6

(d) Derive the expressions for electrostatic potential and electric field intensity due to an electrostatic dipole.

3+2

OR

2 (a) Derive the boundary conditions for the normal and tangential components of electric field intensity $\vec{E}$ and electric flux density $\vec{D}$ at the interface between two perfectly dielectric media.

8

(b) Solve Laplace's equation for the potential field in the homogeneous dielectric region between two concentric conducting spheres with radii a and b, at $V = 0$ at $r = b$ and $V = V_0$ at $r = a$. Assume $b > a$. Find the capacitance between them.

5+3

UNIT - III

3 (a) Using Biot-Savart's law, determine the magnetic field intensity due to an infinitely long steady straight line current.

8

(b) Magnetic field intensity $\vec{H} = 10\,\rho^2\,\hat{a}_\varphi\ A/m$. Determine the current density $\vec{J}$ and the total current in the $\hat{a}_z$ direction passing through the surface $0 \le \rho \le 2,\ 0 \le \phi \le 2\pi,\ z = 0$.

4+4

OR

3 (a) Show that, in free space, the energy stored in a magnetic field of flux density $\vec{B}$ is given by $\xi = \frac{1}{2\mu_0} \int_{allspace} B^2\,dv$.

6

(b) Using Biot-savart's law, show that $\vec{\nabla} \cdot \vec{B} = 0$.

5

(c) The magnetic vector potential of a current distribution in free space is given by $\vec{A} = -\frac{\rho^2}{5}\hat{a}_z\ Wb/m$. Calculate the magnetic flux through the region $2 \le \rho \le 3m,\ \varphi = \pi/3,\ 0 \le z \le 5m$.

5

UNIT - IV

4 (a) Express differential form of Maxwell's equation for sinusoidal time varying fields in phasor notation and derive the vector Helmnoltz equations for $\vec{E}$ and $\vec{H}$ in a charge free $(\rho_v = 0)$, linear, homogeneous, conducting medium $(\sigma \neq 0)$.

4+5

(b) Show that in a good conductor, $\alpha = \beta = \sqrt{\frac{\omega\mu\sigma}{2}}$

Where α is the attenuation factor and β is the phase shift constant.

2+2

(c) Determine the skin depth of copper at a frequency of 100 MHz. Assume 6 = 58 MS/m and $\mu = \mu_o = 4\pi \times 10^{-7}\ H/m$.

3

OR

4 (a) A uniform plane electromagnetic wave with field varying sinusoidally with time, in medium

(1) is incident normally on the surface of medium

(2) Derive the expression for the reflection and refraction co-efficients.

8

(b) Show that, if medium 1 is a perfect dielectric and medium 2 is a perfect conductor, standing waves of $\vec{E}$ and $\vec{H}$ will be formed in medium1. Discuss the phase relationship and the locations of maxima and minima of the resultant fields in medium 1 for this case.

4+4

UNIT - V

5 (a) Determine the total power radiated by a small alternating line current element $I_o dl \cos \omega t$.

12

(b) Discuss the causes and sources of electromagnetic interference.

4

OR

5 (a) Determine the radiation resistance of a small line element of length 3 cm carrying an alternating current of frequency 100 MHz.

6

(b) Discuss different control techniques to suppress electromagnetic interference.

10