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10ES36

Third Semester B.E. Degree Examination, June 2012
Field Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Derive the expression for $\vec{E}$ due to an infinite line of charge. **(08 Marks)**

b. Given $\vec{D} = 5 \sin\theta \, \hat{a}_\theta + 5 \sin\phi \, \hat{a}_\phi$, find the charge density at (0.5m, $\pi/4$, $\pi/4$). **(04 Marks)**

c. Given that $\vec{A} = 30 \, e^{-r} \, \hat{a}_r - 2z \, \hat{a}_z$. Evaluate both sides of the divergence theorem for the volume enclosed by r = 2, z = 0 and z = 5. **(08 Marks)**

2 a. Define electric scalar potential. Derive an expression for potential due to several point charges. **(06 Marks)**

b. A total charge of 40/3 nc is uniformly distributed over a circular ring of radius 2m placed in Z = 0 plane, with center as origin. Find the electric potential at A (0, 0, 5). **(06 Marks)**

c. Discuss the boundary conditions at the interface between two dielectrics of different permittivities. **(08 Marks)**

3 a. Starting from Gauss's law in integral form, derive Laplace's and Poisson's equations. Write Laplace's equation in all the coordinate systems. **(06 Marks)**

b. Determine whether or not the following vectors represent a possible electric field

i) $\vec{E} = 5 \cos z \, \hat{a}_z$ V/m

ii) $\vec{E} = (12yx^2 - 6z^2x) \, \hat{a}_x + (4x^3 + 18zy^2) \, \hat{a}_y + (6y^3 - 6zx^2) \, \hat{a}_z$. **(06 Marks)**

c. Conducting spherical shells with radii a = 10 cm and b = 30 cm are maintained at a potential difference of 100V such that V = 0 at r = b and V = 100V at r = a. Determine V and $\vec{E}$ in the region between the shells. If $\in_r = 2.5$ in the region, determine the total charge induced on the shells and the capacitance there on. **(08 Marks)**

4 a. State Biot-Savart law. Obtain an expression for magnetic field intensity due to straight conductor of finite length. **(07 Marks)**

b. In the region 0 < r < 0.5m, in cylindrical co-ordinates, the current density is $\vec{J} = 4.5e^{-2r} \, \hat{a}_z$ and $\vec{J} = 0$ elsewhere. Use amperes circuital law to find $\vec{H}$. **(05 Marks)**

c. Given the magnetic field $\vec{H} = 2r^2(z + 1) \sin\phi \, \hat{a}_\phi$. Verify Stokes theorem for the portion of a cylindrical surface defined by r = 2, $\frac{\pi}{4} < \phi < \frac{\pi}{2}$, 1 < z < 1.5 and for its perimeter. **(08 Marks)**

PART – B

5 a. Obtain the expression of magnetic force between differential current elements. **(05 Marks)**

b. A point charge Q = 18 nc has a velocity of 5×10^6 m/s in the direction $\vec{a_v} = 0.6\hat{a_x} + 0.75\ \hat{a_y} + 0.3\hat{a_z}$. Calculate the magnitude of the force exerted on the charge by the field :

i) $\vec{E} = -3\hat{a}_x + 4\hat{a}_y + 6\hat{a_z}$ kV/m

ii) $\vec{B} = -3\hat{a}_x + 4\hat{a}_y + 6\hat{a_z}$ mT

iii) $\vec{B}$ and $\vec{E}$ acting together. **(08 Marks)**

c. If $\vec{B} = 0.05x\ \hat{a_y}$ T in a material for which $\chi_m = 2.5$,

find : i) ulr ; ii) ul ; iii) $\vec{H}$; iv) $\vec{M}$; v) $\vec{J}$ and vi) $\vec{J}_b$. **(07 Marks)**

6 a. Write an explanatory note on : Maxwell's equations in point and integral forms applicable to time varying fields. **(05 Marks)**

b. Given $\vec{E} = EmSin(wt - \beta z)\hat{a_y}$ in force space, find $\vec{D}$, $\vec{B}$ and $\vec{H}$. Sketch $\vec{E}$ and $\vec{H}$ at t = 0. **(10 Marks)**

c. Find the induced voltage in the conductor if $\vec{B} = 0.04\hat{a}_y$ T and $\vec{v} = 2.5Sin10^3t\,\hat{a_z}$ m/s, find induced emf, if $\vec{B}$ is changed to $0.04\ \hat{a_x}$ T. **(05 Marks)**

7 a. Starting from Maxwell's equation, derive the wave equation for a uniform plane wave travelling in free space. **(08 Marks)**

b. A 800 MHz plane wave travelling has an average Poynting vector of 8 mW/m^2. If the medium is losses with $\mu_r = 1.5$ and $\in_r = 6$. Find :

i) Velocity of wave
ii) Wavelength
iii) Impedance of the medium
iv) r.m.s. electric field E and
v) r.m.s. magnetic field H. **(08 Marks)**

c. Wet marshy soil is characterized by $\sigma = 10^{-2}$ s/m, $\in_r = 15$ and $\mu_r = 1$. At frequencies 60Hz and 10 GHz indicate whether soil be considered a conductor or a dielectric. **(04 Marks)**

8 a. Explain the reflection of uniform plane waves, with normal incidence at a plane dielectric boundary. **(08 Marks)**

b. A free space-silver interface has Ei = 100 V/m on the free space side. The frequency is 15 MHz and silver constants are $\in_r = \mu_r = 1$, $\sigma = 61.7$ MS/m. Determine E_r and E_t at the interface. **(08 Marks)**

c. Define :

i) Reflection coefficient
ii) Standing wave ratio. **(04 Marks)**

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