DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

Subject: Electromagnetic Fields (PCC-EEE 05)

ASSIGNMENT - 1

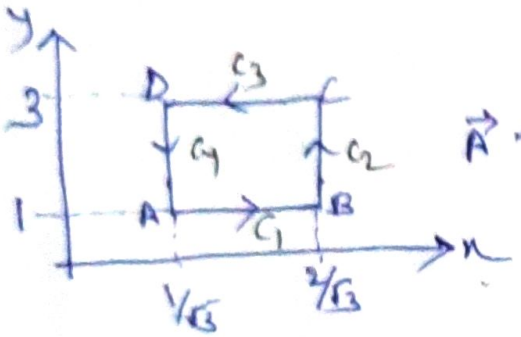
(1) Express the vector

$$B = \frac{10}{\eta} a_\eta + \eta \cos\theta \, a_\theta + a_\phi$$

in cartesian coordinate and find $B(-3, 4, 0)$

Ans:- $B = -2a_x + a_y$

$|B(-3,4,0)| = 2.907$

(2) 

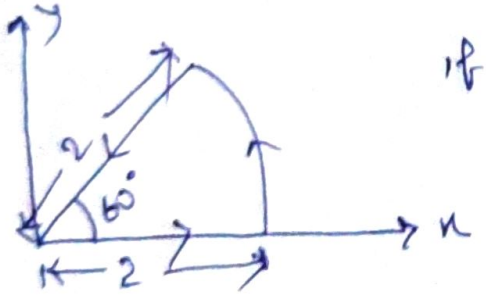
$\vec{A} = xy\,\hat{a}_x + x^2 \hat{a}_y$

calculate the circulation of $\vec{A}$ along the closed path $C(C_1 \to C_4)$

Ans: $\oint_C \vec{A} \cdot d\vec{l} = 1$

(3) Find the unit vector normal to the scalar field $y^2 = 8x$ at $(1,2)$

Ans:- $\hat{a}_{G(1,2)} = \frac{-8\hat{i} + 4\hat{j}}{\sqrt{32}}$

(4) 

If vector A is

$\vec{A} = \rho \cos\phi \, \hat{a}_\rho + z \sin\phi \, \hat{a}_z$

then evaluate $\oint A \cdot dl$ around the path shown in the figure.

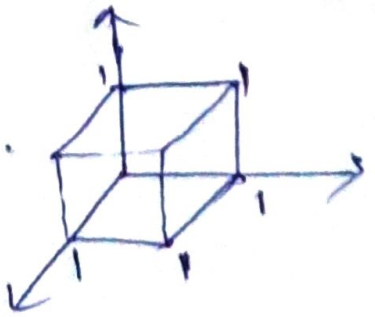
Ans: $\oint_L A \cdot dl = 1$

Hint: Can use stoke's theorem

(5) Evaluate, $\oint\oint_S \vec{F} \cdot d\vec{S}$ where

$\vec{F} = 4xz\,\hat{i} - y^2 \hat{j} + yz\,\hat{k}$

and S is the surface of cube formed by $0 \le x, y, z \le 1$



Ans: $\oint\oint_S \vec{F} \cdot d\vec{S} = 3/2$

Hint: Can use Divergence theorem

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

Subject: Electromagnetic Fields (PCC-EEE 05)

ASSIGNMENT-2

(1) A point charge $Q_1 = 300\ \mu C$ is located at (1, -1, -3) is experiencing a force of $8\hat{a}_x - 8\hat{a}_y + 4\hat{a}_z$ N due to the point charge Q_2 present at (3, -3, -2). Calculate Q_2?

Ans: $Q_2 = -40\ \mu C$

(2) A finite line charge is present along z axis ($z = \pm\infty$) with uniform density 20 nc/m. Calculate the Electric field intensity (2, 0, 0).

Ans: $\vec{E} = 167.12\ V/m\ \hat{a}_x$

(3) Find the force experienced by 50 μC charge present at (0, 0, 5) due to uniformly charged disc with 500 μC charge having radius 5 m and it is placed in $z = 0$ plane.

Ans: $\vec{F} = 16.53\ \hat{a}_z$ N

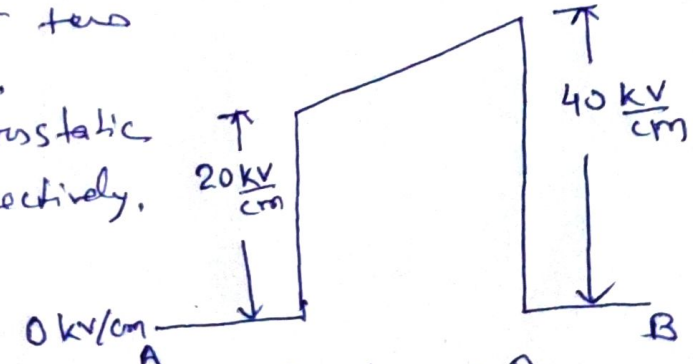
(4) potential field is given as $V = x - y + xy + 2z$

(a) Calculate $\vec{E}$ at (1, 2, 3)

(b) Calculate Electrostatic Energy stored in the cube of side 2 m centered at origin.

Ans: $\vec{E}_{(1,2,3)} = -3\hat{i} - 2\hat{j}$ and, $U = 16\epsilon$ Joule

(5) The Electric field (assumed to be one-dimensional) between two points A and B is shown. Let V_A and V_B be the electrostatic potentials at A and B, respectively. Find the value of $V_A - V_B$?



Ans: 15 Volt

(6) If $\vec{E} = -(2y^3 - 3yz^2)\hat{x} - (6xy^2 - 3xz^2)\hat{y} + (6xyz)\hat{z}$ is the Electric field in a source free region. Then find the Electrostatic potential.

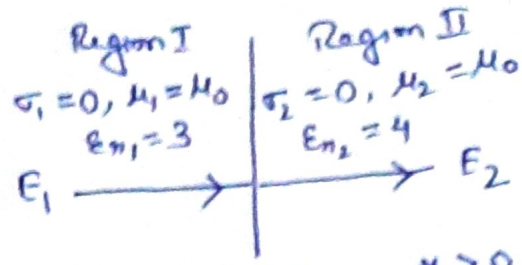
Ans: $2xy^3 - 3xyz^2$

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

Subject: Electromagnetic Fields (PCC – EEE 05)

ASSIGNMENT-3

Q1 A medium is divided into regions I and II about $x=0$ plane, as shown in the figure. An Electromagnetic wave with electric field $\vec{E_1} = 4\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$ is incident normally on the interface from region-1. Find the $\vec{E_2}$ in region-II.



Ans: $3\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$

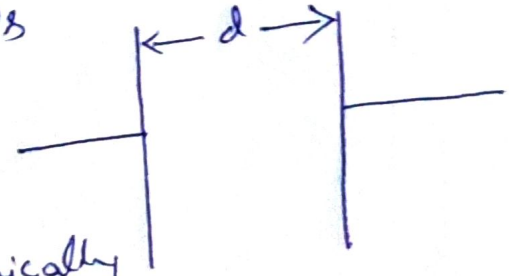
(2) Medium 1 has the electrical permittivity $\varepsilon_1 = 1.5\varepsilon_0$ farad/m and occupies the region to the left of $x=0$ plane. Medium 2 has the electrical permittivity $\varepsilon_2 = 2.5\varepsilon_0$ farad/m and occupies the region to the right of $x=0$ plane. If E_1 in medium 1 is $E_1 = (2a_x - 3a_y + 1a_z)$ volt/m, then find the E_2 in medium 2.

Ans:⇒ $(1.2a_x - 3.0a_y + 1.0a_z)$

(3) The electric field on the surface of a perfect conductor is 2 V/m. The conductor is immersed in water with $\epsilon = 80\epsilon_0$. Find the surface charge density on the conductor.

Ans:⇒ 1.41×10^{-9} C/m²

(4) The parallel-plate capacitor shown in the figure has movable plates. The capacitor is charged so that the energy stored in it is E when the plate separation is d. The capacitor is then isolated electrically and the plates are moved such that the plate separation becomes 2d. At this new plate separation, what is the energy stored in the capacitor.



Ans: 2E

DARBHANGA, COLLEGE OF ENGINEERING, DARBHANGA

Subject: Electromagnetic Fields (PCC-EEE 05)

ASSIGNMENT-4

(1) A magnetic field in air is measured to be

$$\vec{B} = B_0\left(\frac{x}{x^2+y^2}\hat{y} - \frac{y}{x^2+y^2}\hat{x}\right)$$

What current distribution leads to this field?

Ans: $\vec{J}=0$

(2) An infinitely long uniform solid wire of radius a carries a uniform dc current of density $\vec{J}$.

(a) s for $s<a$ and $1/s^2$ for $s>a$

(b) 0 for $s<a$ and $1/s$ for $s>a$

(c) s for $s<a$ and $1/s$ for $s>a$

(d) 0 for $s<a$ and $1/s^2$ for $s>a$

(3) The unit of $\nabla \times \vec{H}$ is

(a) Ampere

(b) Ampere/meter

(c) Ampere/meter^2

(d) Ampere-meter

(4) Deduce an expression for magnetic field intensity H due to an infinitely long current-carrying conductor carrying current I. Use Biot-Savart law.

(5) The magnetic field at any point on the axis of a current carrying circular coil will be:

(a) perpendicular to the axis

(b) parallel to the axis

(c) at an angle 45° with axis

(d) zero.

Code : 031506

B.Tech 5th Semester Exam., 2013

ELECTROMAGNETIC FIELD THEORY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Fill in the blanks (any *seven*) : 2×7=14

(a) Divergence of a curl of a vector is ——.

(b) Energy density in the electrostatic field is ——

(c) The value of relative permeability is slightly less than one for —— and slightly greater than one for ——.

(d) Tangential component of electric field is —— across the interface between two dielectric media.

(e) Surface impedance of good conductor is just equal to ——

(f) For uniform plane wave E field and H field has —— in the direction of propagation.

(Turn Over)

(g) VSWR varies from —— to ——.

(h) Short circuited quarter wave section and open end half-wave section is analogous to ——.

(i) If the standing wave of voltage slope is up towards the termination, then the reactance will be ——.

(j) The quality factor of a resonant section of transmission line is equal to the ratio of —— per unit length to —— per unit length.

2. *(a)* For a two-dimensional system $r = \sqrt{x^2 + y^2}$, determine $\nabla^2 V$, when $V = \ln \frac{1}{r}$.

(b) Find out the divergence of vector and interpret it by giving physical examples.

(c) State and prove divergence theorem. 4+8+2=14

3. *(a)* State and prove uniqueness theorem.

(b) Find the capacitance of two spheres, whose separation d is very much larger than their radii R. Hence show that the capacitance of sphere above an infinite ground plane is independent of the height h above the plane when $h >> R$. 4+(5+5)

(Continued)

4. (a) Describe magnetic vector potential.

(b) Explain Ampere force law.

(c) Find the magnetic field inside a solid conductor carrying a direct current I and hence obtain total magnetic flux per unit length within the conductor. 5+3+6

5. (a) Obtain continuity equation for time-varying field.

(b) Explain in consistency of Ampere circuital law.

(c) The electric vector $\vec{E}$ of a electro-magnetic wave in free space is given by the expression

$$E_y = A\cos\omega\left(t - \frac{z}{c}\right)$$

Using Maxwell's equation for free space condition, determine magnetic vector $\vec{H}$. 5+5+4

5. (a) Find the component of $\vec{E}$ and $\vec{H}$ in the direction of the propagation for uniform plane wave.

(b) Establish the relation between $\vec{E}$ and $\vec{H}$ in a uniform plane wave.

(c) Show that the function

$$F = e^{-\alpha z}\sin\frac{\omega}{v}(x - vt)$$

satisfies the wave equation

$$\nabla^2 F = \frac{1}{c^2}\frac{\partial^2 F}{\partial t^2}$$

provided that the wave velocity is given by

$$v = c\left(1 + \frac{\alpha^2 c^2}{\omega^2}\right)^{-\frac{1}{2}}$$ 4+6+

7. (a) Find the reflection coefficient by perfect dielectric for parallel polarization and hence obtain Brewster angle.

(b) Discuss surface impedance. 11+

8. (a) State and prove Poynting theorem.

(b) Discuss Smith chart. (4+6)+

9. (a) Find the quality factor of a resonant transmission line section.

(b) Find the voltage step up in quarter wave line. 9+

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Code : 031506

B.Tech 5th Semester Exam., 2014

ELECTROMAGNETIC FIELD THEORY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Fill in the blanks (any *seven*) : 2×7=14

(a) The curl of a gradient of a scalar quantity is ——.

(b) Energy density in the magnetic field is ——.

(c) Normal component of electric flux density is ——, across the interface between two dielectric media.

(d) The relation of depth of penetration in good conductor is given by ——.

(e) The direction of magnetic vector potential is same as the direction of ——.

(f) VSWR for a matched termination is ——.

(g) If the standing wave of voltage slopes down towards the termination, then the terminating reactance will be ——.

(h) Quarter wave section is an ——.

(i) Uniform plane waves are —— waves.

(j) Two conductors carrying current in opposite direction experience —— force.

2. *(a)* Derive an expression for potential due to a long pair of parallel wires.

(b) Deduce the equation for equipotential surfaces for parallel line charges.

(c) Find the capacitance of parallel cylindrical conductors having equal radii a and separation between their axes as b. 14

3. *(a)* Find the conductor properties and boundary conditions.

(b) A point charge q is located at a distance h above an infinite conducting plane. Using the method of images, find the displacement density normal to the plane and hence surface charge density. Also obtain total charge on the infinite conducting plane. 6+8=14

(Continued)

4. (a) Obtain curl of a vector and interpret it.

(b) Prove Stokes' theorem.

(c) Discuss ampere force law. 7+4+3=14

5. (a) Obtain two Maxwell's equations which deviate from steady-state condition.

(b) Using $\nabla \cdot \vec{D} = \rho$, Ohm's law and the equation of continuity, show that if at any instant a charge density ρ existed within a conductor, it would decrease to $\frac{1}{e}$ times this value in time $\frac{\varepsilon}{\sigma}$ seconds. 9+5=14

6. (a) Discuss the propagation in a conducting medium and hence obtain the expression for attenuation constant α and phase-shift constant β.

(b) Find the values of α and β for good conductor and good dielectric. 7+7=14

7. (a) Find out the reflection coefficient for perfect conductor in the case of normal incidence.

(b) The electric field of a uniform plane electromagnetic wave in free space is 1 volt/metre and frequency is 300 MHz.

If a very large thick flat copper plate is placed normal to the direction of wave propagation, determine—

(i) $\vec{E}$ and $\vec{H}$ at the surface of plate;

(ii) depth of penetration;

(iii) conduction current density at the surface;

(iv) conduction current density at a distance of 0·01 mm below the surface;

(v) linear current density, J_s;

(vi) surface impedance;

(vii) power loss per square metre of surface area.

[Take : $\sigma_{cu} = 5 \cdot 8 \times 10^7$ v/m.] 6+8=14

8. (a) Discuss instantaneous, average and complex Poynting vectors.

(b) Obtain power loss in a plane conductor.

(c) A short vertical transmitting antenna erected on the surface of a perfectly conducting earth produces an effective field strength, $E_{eff} = 100 \sin\theta$ mV/m at points a distance one mile from the antenna. Compute Poynting vector and total power radiated. 5+4+5=14

9. *(a)* Discuss UHF line as circuit element and obtain input-input resistance of the line for resonant length.

(b) Discuss quarter wave line as a transformer.

(c) A lossless transmission line has a characteristic impedance of 300 Ω and is one-quarter wavelength long. What will be the voltage at the open-circuited receiving end, if sending end is connected to a generator which has a 50-Ω internal impedance and generated voltage of 10 volts? 5+5+4=14

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Code : 031506

B.Tech 5th Semester Examination, 2016

Electromagnetic field Theory

Time : 3 hours *Full Marks : 70*

Instructions :

(i) There are Nine Questions in this paper.

(ii) Attempt Five questions in all.

(iii) Question No. 1 is compulsory.

(iv) The marks are indicated in the right-hand margin.

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1. Choose the correct alternatives for any seven of the following and explain: 7×2=14

   (i) The electric field on equipotential surface is:

   (a) Unity

   (b) always parallel to the surface

   (c) always perpendicular to the surface

   (d) zero

   (ii) Electric field in a region containing space charge can be found using:

   (a) Laplace's equation

   (b) Poisson's equation

   (c) Coulomb's law

(d) Helmholtz equation

(iii) Electrostatic field is:

(a) solenoidal

(b) conservative

(c) both solenoidal & conservative

(d) sometimes solenoidal, sometimes conservative

(iv) One Weber is equal to:

(a) 10^6 lines

(b) 44×10^{-7} lines

(c) 10^{12} lines

(d) 10^8 lines

(v) Two thin parallel wires carry currents along the same direction. The force experienced by one due to the other is:

(a) parallel to the lines

(b) perpendicular to the lines and attractive

(c) perpendicular to the lines & repulsive

(d) zero

(vi) The magnetic field at any point on the axis of a current-carrying circular coil will be:

(a) perpendicular to the axis

(b) parallel to the axis

(c) at an angle 45° with axis

(d) zero

(vii) To apply Gauss's law, the Gaussian surface should be chosen in such a way that field is:

(a) perpendicular

(b) tangential

(c) either perpendicular or tangential

(d) parallel to the surface

(viii) Gradient of a scalar function results in a:

(a) vector function

(b) scalar function

(c) peak function

(d) periodic function

2. (a) Derive an expression for electric field E due to surface (sheet) charge uniformly distributed over an infinite plane having density ς_s c/m V.

(b) State and explain the following:

(i) Strokes theorem

(ii) Helmholtz's theorem

(c) Deduce boundary condition of electric field for Dielectric- Dielectric boundary.

(d) Deduce an expression for magnetic field intensity H due to an infinitely long current-carrying conductor carrying-current I. Use Biot-Savart law. 14

3. (a) Derive an expression for Lorentz force on a moving charge in an electromagnetic field.

(b) What are conduction and displacement currents?

(c) From the concept of displacement current derive an expression for modified Ampere's law.

(d) Write and explain differential and integral forms of Maxwell's equations. 14

4. (a) A plane polarized wave is travelling along Z-axis. Show graphically the variation of E and H with Z. Show that $E_y / H_z = 377\Omega$ for the wave.

(b) Develop the analogy between the uniform plane EM waves and the transmission line.

(c) A uniform transmission line has constants R=12 mΩ, G=0.8 μ Ω-1/m, L=1.3 μ H/m and C =0.7 nF/m. At 5 kHz, find

(i) impedance

(ii) dB attenuation in 2 km

14

5. (a) Establish the relation $\nabla \times H = J + \partial D / \partial t$. The symbol used has usual meaning.

(b) What do you mean by linearly polarized plane E.M. waves in free space?

(c) What do you mean by depth of penetration in such medium ? If the penetration depth is 1.35 m at 50 Hz. what will this be at 10 kHz? 14

6. (a) Write down general procedure for solving Poisson's and Laplace's equation.

(b) Deduce an expression of energy density in electrostatic field.

(c) What is meant by the following?

(i) Transformer and motional e.m.f.

(ii) Electric potential and potential gradient 14

7. (a) Find curl H at the origin, where H=2Y $i\times -(x^2 + z^2)i_y$ +3y i_z.

(b) Show that

(i) $\nabla \times (fG) = \nabla f \times G + g\nabla \times G$

(ii) $\nabla \times (\nabla \times F) = \nabla(\nabla . F) - \nabla^2 F$.

(c) It is required to hold four equal point charges + q each in equilibrium at the corners of a square. Find the point charge which will do this if placed at the centres of the square. 14

8. (a) The magnetic field component of a plane wave in a lossless dielectric $\mu_r = /$ is H=30 sin $(\lambda\pi \times 10^8 t - 5\times)$ az mA/m. find

(i) $\in_r$

(ii) the wavelength and wave velocity

(iii) the wave impedance

(iv) the polarization of the wave

(v) the corresponding electric field component

(b) Develop the analogy between the uniform plane EM waves and the electric transmission line. 14

9. (a) What are skin effect and skin depth?

(b) Show that in case of semi-infinite solid conductor, the depth d is given by $\boxed{?} = \sqrt{\frac{2}{\omega\mu\sigma}}$ where ω, μ & σ have their usual meaning.

(c) What is polarization of electro-magnetic wave?

(d) Explain the significance of pointing vector.

14

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Code : 031506

B.Tech 5th Semester Exam., 2017

ELECTROMAGNETIC FIELD THEORY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct alternatives for any *seven* of the following : 2×7=14

(a) A Gaussian surface for application is

(i) a closed surface

(ii) a symmetrical closed surface

(iii) a semi-closed surface

(iv) any surface

(b) Which one of the following statements is not characteristic of a static magnetic field?

(i) It is conservative

(ii) It is solenoidal

(iii) It has link and sources

(iv) Magnetic flux lines are always closed

(c) Electric field in a region containing space charges can be found using

(i) Laplace's equation

(ii) Poisson's equation

(iii) Coulomb's law

(iv) Helmholtz equation

(d) In a transmission line, electromagnetic energy is transported by

(i) the flow of electrons

(ii) the flow of electrons and holes

(iii) the associated electric and magnetic field

(iv) electric field only

(e) In a certain region, the electric field $E = 0$, potential V, there must be

(i) zero

(ii) a constant

(iii) a function of position

(iv) infinity

(f) The work done by the force $F = 4a_x - 3a_y + 2a_z$ N in giving a 1 nC charge a displacement of $10ax + 2ay - 7az$ m is

(i) 103 nJ

(ii) 60 nJ

(iii) 64 nJ

(iv) 20 nJ

(g) Which of the following is a mathematically incorrect expression?

(i) grad div

(ii) curl grad

(iii) div grad

(iv) curl curl

(h) The flux through each turn of a 100 turn coil is $(t^3 - 2t)$ m Wb, where t is in seconds. The induced e.m.f. at $t = 2$s is

(i) 1 V

(ii) −1 V

(iii) 4 mV

(iv) 0·4 V

(i) Which is the major factor for determining whether a medium is free space, lossless dielectric, loss dielectric or good conductor?

(i) Attenuation constant

(ii) Constitutive parameters (α, ε, μ)

(iii) Loss tangent

(iv) Reflection coefficient

2. Answer the following : 3½×4=14

(a) Find the divergence and curl of the following vectors $A = x^2yz\, a_x + xz\, a_z$.

(b) Given the point $P(-2, 6, 3)$. Express P in cylindrical and spherical coordinates.

(c) A point charge of 30 nC is located at the origin while plane $y = 3$ carries charge 10 nC/m^2. Find D at (0, 4, 3).

(d) A thin ring of radius 5 cm is placed on the plane $z = 1$ cm so that its centre is at (0, 0, 1) cm. If the ring carries 50 mA along a_ϕ, find H at (0, 0, −1) cm.

3. (a) Derive the following equations : 7

(i) $\nabla \times H = J$

(ii) $\nabla \times B = 0$

(b) Determine the self-inductance of a coaxial cable of inner radius a and outer radius b. 7

4. (a) State and explain the significance of Helmholtz's theorem. 5

(b) Write Lorentz force equation. Hence obtain the expression of force acting on a straight conduction of length L in a uniform magnetic field B. 5

(c) Find the force on a straight conductor of length 0·20 m carrying a current of 5·0 A in the az direction, where the field is $B = 4 \times 10^3 (ax + ay)$ tesla. 4

5. (a) Explain the following : 6

(i) Divergence of a vector field

(ii) Gradient of a scalar field

(b) Consider the volume current density distribution in cylindrical coordinates as

$$J(r, \phi, z) = 0 \quad , \quad 0 < r < a$$
$$J(r, \phi, z) = J_0 (r / a) a_z, \quad a < r < b$$
$$= 0 \quad , \quad b < r < x$$

Find the magnetic field intensity H in various regions. 8

6. Answer the following : 14

(a) Derive wave equation for lossy dielectric medium.

(b) What is propagation constant?

(c) Derive the expression for intrinsic impedance for lossy dielectric medium.

7. (a) Transform a vector $A = ya_x - xa_y + za_z$ into cylindrical coordinate. 5

(b) State the expression of divergence for three-coordinate system. 4

(c) In electrostatic field problem, the electric field is given by $E = -\text{grad}\, V$, where V is the scalar field potential. If $V = r^2 \phi - 2\theta$ in spherical coordinate, find E. 5

8. (a) Determine the charge densities due to each of the following electric flux densities : 8

(i) $D = (r \sin\phi)\hat{r} + (3r\cos\phi)\hat{\phi} + (z^2)\hat{k}$

(ii) $D = \left(\frac{2\cos\theta}{r^3}\right)\hat{r} + \left(\frac{\sin\theta}{r^3}\right)\hat{\theta}$

(b) A spherical charge distribution is given by

$$\rho = \left(\rho_0 \frac{r}{a}\right), \quad r < a$$
$$0 \quad , \quad r > a$$

Find V and E everywhere. 6

9. Write short notes of the following : 3½×4=14

(a) Stokes theorem

(b) Green's theorem

(c) Helmholtz theorem

(d) Laplace and Poisson's equation

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