EC44

NEW SCHEME

USN

Fourth Semester B.E. Degree Examination, July/August 2004

BM/EC/EE/TE/ML/IT

Field Theory

Time: 3 hrs.] [Max.Marks : 100

Note: ***Answer any FIVE full questions.***

1. (a) Explain Coulomb's law. Justify that the force field in the region of an isolated charge Q is spherically symmetric. **(4 Marks)**

   (b) Develop an expression for the electric field intensity when charge is distributed uniformly over a surface. **(8 Marks)**

   A line charge of 2 nc/m lies along y-axis while surface charge densities of 0.1 and $-0.1\ nc/m^2$ exist on the plane Z=3 and Z=−4m respectively. Find the electric field intensity at a point $(1,-7,2)$.

   (c) State and explain Gauss' law and verify it for a point charge.

   A point charge Q=30nc is located at the origin in Cartesian coordinates. Find the electric flux density $\vec{D}$ at $(1,3,-4)m$. **(8 Marks)**

2. (a) Find an expression establishing the relationship between electric field intensity and gradient of potential.

   Find the electric field strength $\vec{E}$ at the point $(1,2,-1)$ given the potential $V = 3x^2y + 2yz^2 + 3xyz$. **(10 Marks)**

   (b) Derive an expression for the energy stored in a region of continuous charge distribution.

   A parallel plate capacitor for which $C = \epsilon\ A/d$ has a constant voltage V applied across the plates. Find the stored energy in the electric field. **(10 Marks)**

3. (a) Discuss the three basic principles that apply to conductors in electrostatic fields. Indicate how these principles with a given knowledge of potential field help to calculate certain field quantities.

   If the potential field $\vec{V}$ is $\vec{V} = 100(x^2 - y^2)$ find $\vec{E}, V$ at a point $(2,-1,3)$ and the equation representing the locus of all points having a potential of 300V. **(6 Marks)**

   (b) Discuss the behaviour of fields at the interface between a perfect dielectric and a conductor. **(8 Marks)**

   (c) State and discuss uniqueness theorem. **(6 Marks)**

4. (a) State and discuss Ampere's circuital law and apply it to the case of an infinitely long co-axial transmission line carrying a uniformly distributed current, to calculate the magnetic field intensity. **(8 Marks)**

   (b) If the magnetic field intensity in a region is $\vec{H} = x^2\vec{a}_x + 2yz\vec{a}_y + (-x^2)\vec{a}_z$, find the current density at the origin. **(4 Marks)**

   (c) Discuss the concept of vector magnetic potential and arrive at an expression for it.

   Given the vector magnetic potential $\vec{A} = x^2\vec{a}_x + 2yz\ \vec{a}_y + (-x^2)\vec{a}_z$, find the magnetic flux density. **(8 Marks)**

Contd.... 2

5. (a) Explain the nature of the force when a charged particle is moving through steady electric and magnetic fields.

Find an expression for force on differential current element moving in a steady magnetic field.

Deduce the result to a straight conductor in a uniform magnetic field. **(8 Marks)**

(b) A conductor 4m long lies along the y-axis with a current of 10.0A in the $\vec{a}_y$ direction. Find the force on the conductor if the field in the region is $\vec{B} = 0.05\ \vec{a}_x$ Tesla. **(10 Marks)**

(c) Discuss the magnetic boundary conditions to apply to $\vec{B}, \vec{H}$ *and* $\vec{M}$ at the interface between two different magnetic materials. **(8 Marks)**

6. (a) Discuss the physical significance of displacement current and justify that for the case of a parallel plate capacitor the displacement current is equivalent to conduction current.

Comment on the ratio of magnitudes of conduction current density to displacement current density.

A circular cross-section conductor of radius 1.5mm carries a current $i = 5.5\ sin(4 \times 10^{10} t)\mu A$. Find the amplitude of the displacement current density if $\sigma = 35\ mho/m$ *and* $\in r = 10$. **(10 Marks)**

(b) Derive Maxwell's equations in point form Gauss law for electric and magnetic fields.

Given $\vec{E} = E_m\ sin(\omega t - \beta I)\vec{a}_y$ in free space, calculate $\vec{D}, \vec{B}$ *and* $\vec{H}$. **(10 Marks)**

7. (a) Discuss the propagation of uniform plane waves in a lossless medium.

A uniform plane wave $\vec{E}_y = 10sin(2\pi \times 10^8\ t - \beta x)$ is traveling in x-direction in free space. Find i) Phase constant , ii) Phase velocity and iii) the expression for $\vec{H}_z$. Assume $\vec{E}_z = 0 = \vec{H}_y$. **(10 Marks)**

(b) Define Poynting vector and explain the power flow associated with it.

The electric field intensity at a distance of 10 km in free space from a radio station was found to be 2.2 mv/m. Calculate

i) the power density and ii) The total power radiated from the station.

Assume the radiation to be spherically symmetric. **(10 Marks)**

8. Write notes on :

a) Gauss' divergence theorem **(5 Marks)**

b) Equation of continuity. **(5 Marks)**

c) Solution of Laplace's equation **(5 Marks)**

d) Magnetic circuits. **(5 Marks)**

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EC44

NEW SCHEME

Reg. No. | | | | | | | | | | |

Fourth Semester B.E. Degree Examination, January/February 2006

BM/EC/EE/TE/ML/IT

Field Theory

Time: 3 hrs.) (Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. Assume the missing data, if any.

1. (a) Explain electric field intensity at a point in an electric field produced by a point charge. Show that the electric field intensity at any point due to an infinite sheet of charge is independent of the distance to the point from the sheet. **(8 Marks)**

(b) Explain the concept of work and potential as applied to an electric field and hence obtain an expression for the potential difference between two points in an electric field produced by a point charge. **(6 Marks)**

(c) Find the electric field at the origin due to a point charge of $6.44 \times 10^{-9} C$ located at $(-4, 2, -3)m$ in the Cartesian coordinate system. **(6 Marks)**

2. (a) State and prove Gauss law and determine the field due to an infinite line charge using the same. **(10 Marks)**

(b) With usual notations establish the relationship between electric field intensity and the electric potential. **(4 Marks)**

(c) Given the potential field $V = 50 \times X^2 Y Z + 20 Y^2$ Volts in free space, find the voltage at a point $P(1, 2, -3)$ and the field strength at P. **(6 Marks)**

3. (a) Using Laplace's equation, prove that the electric potential at any point distant r in the space between 2 charged concentric spheres of radii R_1 and R_2 as

$$V = V_0 \left[\frac{\frac{1}{r} - \frac{1}{R_2}}{\frac{1}{R_1} - \frac{1}{R_2}} \right].$$

(8 Marks)

(b) With usual notations derive boundary conditions at the boundary between a dielectric and a conductor in an electric field. **(8 Marks)**

(c) Prove that the potential field given by $V = 2x^2 - 3y^2 + z^2$ satisfies Laplace equation. **(4 Marks)**

4. (a) Using the concept of volume energy density in an electric field, find the total energy stored in :

i) A parallel plate system

ii) Two concentric spherical conductors. Hence find their capacitances. **(8 Marks)**

(b) Show that the magnetic field intensity at the end of a long solenoid is one half of that at the center. **(6 Marks)**

(c) Derive an expression for the equation of continuity. **(6 Marks)**

Contd.... 2

5. (a) State and prove Ampere's circuital law and apply it to a straight solid cylindrical conductor to calculate the magnetic field intensity. **(8 Marks)**

(b) Discuss the concept of vector magnetic potential and hence show that $\vec{A} = \frac{\mu_0}{4\pi} \int \frac{\vec{J}}{r} dv$; where $\vec{A}$ is the vector magnetic potential and $\vec{J}$ is the current density. **(6 Marks)**

(c) Find the magnetic field intensity at the center of a square of sides equal to 5m and carrying current of 10A. **(6 Marks)**

6. (a) Derive an expression for the force on a differential current element placed in a magnetic field. Also obtain an expression for the emf induced between the two ends of a conductor due to its motion in a steady magnetic field. **(8 Marks)**

(b) Find the frequency at which the conduction current density and the displacement current density are equal in a medium with

$$\sigma = 2 \times 10^{-4}\ mho/m \ and \ \in_r = 81$$ **(6 Marks)**

(c) Starting from Faraday's law of electromagnetic induction derive the Maxwell's equation $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ **(6 Marks)**

7. (a) State and prove Poynting's theorem. **(10 Marks)**

(b) A radio station transmits power radially around the spherical region. The desired electrical field intensity at a distance of 10 km from the station is 1mV/m. Calculate the corresponding H, P and the station power. **(10 Marks)**

8. Write explanatory note on :

(a) Divergence theorem

(b) Biot-Savart's law

(c) Wave propagation in a good conducting medium

(d) Inductance of a co-axial cable. **(5×4=20 Marks)**

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EC 44

USN | | | | | | | | | | |

NEW SCHEME

Fourth Semester B.E Degree Examination, July 2006
EE / EC / TE / IT / ML / BM
Field Theory

Time: 3 hrs.] [Max. Marks: 100

Note: *1. Answer any FIVE full questions.*
2. Assume any missing data.

1 a. State and explain coulomb's law in the vector form. Mention the units of each term involved. **(06 Marks)**

b. Explain the terms i) Electric field intensity and ii) Electric potential. Also bring out the relation between them. **(06 Marks)**

c. Point charges of 50nc each are located at A(1, 0, 0), B(-1, 0, 0), C(0, 1, 0) and D(0, -1, 0)m. Find the total force on the charge at A. Also find the electric field intensity at A. **(08 Marks)**

2 a. Explain the concept of work and potential as applied to an electric field and hence obtain an expression for the potential difference between two points in an electric field produced by a point charge. **(06 Marks)**

b. Find electric field intensity at P(0, -h, 0)m due to a line charge of finite length along Z axis between A(0, 0, Z_1)m and B(0, 0, Z_2)m. **(06 Marks)**

c. A line charge of total charge 1μc is placed between A(0, 0, 1) and B(0, 0, 2)m. Find electric field intensity at (i) P_1(0, 0, 0)m and (ii) P_2(0, 1, 1)m. **(08 Marks)**

3 a. Starting from Gauss's law, arrive at Poisson's equation and Laplace equation. Write Laplace equation in explicit form in
i) Cartesian co-ordinate system and
ii) Cylindrical co-ordinate system. **(06 Marks)**

b. Obtain an expression for the electric field intensity due to an infinite line charge along z axis having a uniform charge of P_l c/m. using Gauss's law. **(06 Marks)**

c. Using Laplace equation, find an expression for the electric potential at any point in an infinitely long co-axial cable with inner radius a_m and outer radius b_m. **(08 Marks)**

4 a. Discuss the boundary conditions at the interface between two dielectrics of different permitivies. **(06 Marks)**

b. Find the stored energy in a system of four identical charges of 4nc at the corners of a square of side 1m. What is the stored energy if only two charges are placed at the corners of the square. **(06 Marks)**

c. Find the potential and volume charge density at P(0.5, 1.5, 1)m in free space given the potential field as under
i) $V = 2x^2 - y^2 - z^2$ volt ii) $V = 6\rho\phi z$ volt. **(08 Marks)**

5 a. State and explain Biot Savart's law. Using this, find the magnetic field intensity in the vicinity of an infinitely long, straight, filamentary current I Ampere along Z-axis. **(10 Marks)**

b. State and discuss Ampere's circuital law. Write also in point form. Determine $\vec{H}$ for a solid cylindrical conductor of radius a where current I is uniformly distributed over the cross section. **(10 Marks)**

Contd...2

6 a. Discuss the boundary conditions at the interface between two media of different permeabilities. **(06 Marks)**

b. State and explain Faraday's law of electromagnetic induction. Write also in point form. **(06 Marks)**

c. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of length 60cm and of diameter 6cm, given that medium is air. Derive the expression used. **(08 Marks)**

7 a. Starting from Maxwell's equations derive the wave equation for sinusoidal waves in a good dielectric medium. **(08 Marks)**

b. Derive the wave equation for a wave in conducting medium and hence explain the terms 'Skin depth'. **(06 Marks)**

c. State and prove Poynting's theorem. **(06 Marks)**

8 Write short notes on:

a) Energy density in an electrostatic field
b) Continuity equation
c) Force between two differential current elements,
d) Vector magnetic potential. **(20 Marks)**

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EC44

USN | | | | | | | | | | |

NEW SCHEME

Fourth Semester B.E. Degree Examination, Dec. 06 / Jan. 07
EC/EE/BM/TE/ML/IT
Field Theory

Time: 3 hrs.] [Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Assume the missing data, if any.

1 a. Charge is uniformly distributed on a circular ring of radius a. Find the vector E at a height h (h < a), along the axis normal to the plane of the ring charge. **(05 Marks)**

b. Charges of 20 nC and -20 nC are located at (3,0,0) and (-3,0,0) respectively. Let $\varepsilon = \varepsilon_0$. Determine |E| at P(0,y,0). **(05 Marks)**

c. Find the electric field E at origin, if the following charge distributions are present in free space:
- Point charge 12 nC at P(2,0,6)
- Uniform line charge of linear charge density 3 nC/m at x = 2, y = 3
- Uniform surface charge of density 0.2 nC/m^2 at x = 2. **(10 Marks)**

2 a. Derive an expression for field due to a uniformly charged infinite plane sheet, using Gauss's law. **(05 Marks)**

b. A charge Q is uniformly distributed in a square ring of side '*l*'. Find E and V at the centre of the ring. **(05 Marks)**

c. There exists a potential of V = -2.5 volts on a conductor at 0.02 m and V = 15 volts at r = 0.35 m. Determine E and D by solving the Laplace's equation in spherical coordinates representing the potential system. **(10 Marks)**

3 a. Let $\overline{D} = \left(2y^2z - 8xy\right)\overline{a}_x + \left(4xyz - 4x^2\right)\overline{a}_y + \left(2xy^2 - 4z\right)\overline{a}_z$. Determine the total charge within a volume of 10^{-14} m^3 located at P(1,-2,3). **(05 Marks)**

b. Derive the boundary conditions on E and D at the interface of perfect dielectrics. **(05 Marks)**

c. State and prove Maxwell's Divergence theorem applied to electrostatic fields. **(10 Marks)**

4 a. State and prove Uniqueness theorem. **(05 Marks)**

b. Given vector $E = (12yx^2 - 6z^2x)a_x + (4x^3 + 18zy^2)a_y + (6y^3 - 6zx^2)a_z$, check whether it represents a possible electric field. **(05 Marks)**

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

Contd.... 2

5 a. The conducting triangular loop in fig.5(a) carries a current of 10 A. Find vector H at (0,0,5) due to side 1 of the loop. **(05 Marks)**

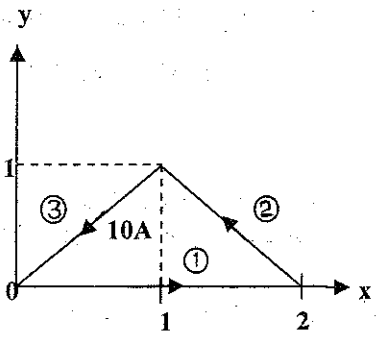

Fig.5(a)

b. A current element 4 cm long is along y-axis with a current of 10 mA flowing in y-direction. Determine the force on the current element due to the magnetic field, if the magnetic field H = [5 a_x / μ] A/m. **(05 Marks)**

c. State Biot-Savart's law. Determine the flux density at a given point due to a current carrying element of finite length and extend it for the case of infinitely long straight conductor. **(10 Marks)**

6 a. Derive the boundary conditions on H and B. **(05 Marks)**

b. Explain the concept of scalar and vector magnetic potentials. **(05 Marks)**

c. A parallel plate capacitor with plate area of 5 cm^2 and plate separation of 3 mm has a voltage of $50\sin 10^3 t$ Volts applied to its plates. Calculate the displacement current assuming $\varepsilon = 2\varepsilon_0$. **(10 Marks)**

7 a. With suitable assumptions, workout the solution of wave equation for uniform plane wave propagating in free space. **(10 Marks)**

b. Derive the wave equation for vector E and H fields in a conducting medium. **(10 Marks)**

8 Write explanatory notes on:

a. Energy density in electric field.

b. Force between two current elements.

c. Maxwell's equations in point and integral forms for time varying fields.

d. Wave propagation in lossy dielectric. **(20 Marks)**

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EC44

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NEW SCHEME

Fourth Semester B.E. Degree Examination, July 2007
EC / TE / EE / IT / ML / BM
Field Theory

Time: 3 hrs.] [Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. State Coulomb's law in complete form. **(05 Marks)**

b. State Guass theorem. Mention nature of Guassian surface. **(05 Marks)**

c. Determine electric flux density D in Cartesian co-ordinates caused at P(6, 8, -10) by

i) A point charge of 30 mC at origin

ii) An infinite line charge with $\rho_l = 40\mu C/m$ on $x = 0 ; y = 0$

iii) A surface charge with $\rho_s = 57.2\mu C/m^2$ on the plane $z = 9$ m. **(10 Marks)**

2 a. Show that $E = -\nabla V$. **(06 Marks)**

b. A total charge of 40 nC is uniformly distributed around a ring of radius 2m, with it's center located at origin (0, 0, 0) and lying in the plane z = 0. Determine electric potential at (0, 0, 5) m. Also determine the potential at (0, 0, 5), if all charge of 40 nC were to be concentrated at origin. **(07 Marks)**

c. Determine work done in carrying a charge of –2 C from (2, 1, –1) to (8, 2, –1) in the electric field $E = y\, a_x + x\, a_y$ v/m, (in Cartesian co-ordinates) considering the path along the parabola $x = 2y^2$. **(07 Marks)**

3 a. Using Laplace equation derive an expression for capacitance for concentric spherical capacitor. **(08 Marks)**

b. Find stored energy in a system of four identical charges of 4 nC, at the corners of a square of side 1m. Also determine energy density at the center of the square. **(06 Marks)**

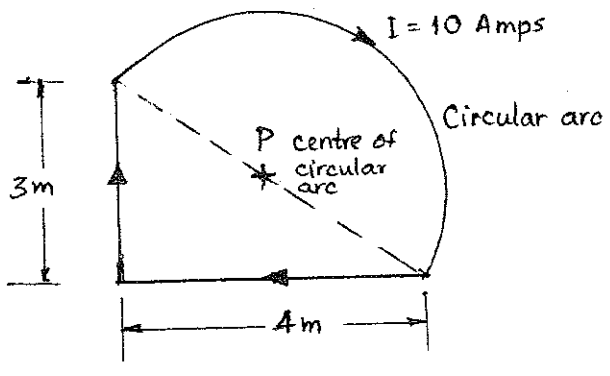
c. With usual notation derive the expression $\nabla . J = -\frac{\partial \rho_v}{\partial t}$. **(06 Marks)**

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

b. State and prove uniqueness theorem. **(06 Marks)**

c. The region $z < 0$ is composed of a uniform dielectric material with $\varepsilon_r = 3.2$ and the region $z > 0$ is characterized by $\varepsilon_r = 2$. If $D_1 = (-30a_x + 50a_y + 70a_z)nC/m^2$, determine i) D_2 ii) θ_1 iii) θ_2 **(06 Marks)**

5 a. Using Biot Savert's law, determine magnetic flux density at 'P', for the current loop shown in Fig.5(a)



(08 Marks)

Contd.... 2

b. Clearly differentiate between scalar magnetic potential and vector magnetic potential. **(05 Marks)**

c. Given $H = 20r^2 a_\phi$ A/m i) Determine the current density J ii) Also determine the total current that crosses the surface r = 1m, $0 < \phi < 2\pi$ and z = 0 (in cylindrical coordinates). **(07 Marks)**

6 a. Explain Faraday's laws applied to
   i) Stationary path, changing field and
   ii) Steady field moving circuit.
   Derive necessary relationships. **(10 Marks)**

b. For the Faraday disc generator shown in Fig.6(b), determine open circuit voltage. The circular disc is of radius 'a', rotates at a constant angular velocity 'ω' rad/sec in a magnetic field of B_{az} $\omega b/m^2$. Two brushes are put, at the axis and rim of the disc.

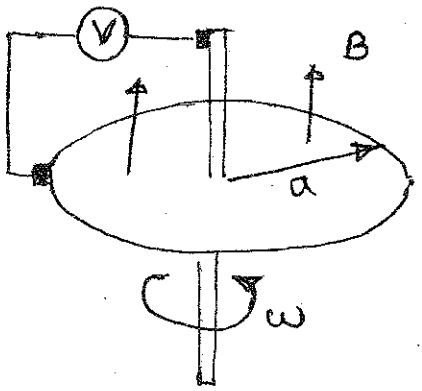


Fig.6(b) **(05 Marks)**

c. Determine inductance of a solenoid carrying N turns on a magnetic core of axial length 'l' meters and cross sectional area of 'A' m^2. **(05 Marks)**

7 a. List Maxwell's equations in differential form for both steady fields and time varying fields. **(08 Marks)**

b. State and prove Poynting theorem. **(06 Marks)**

c. Derive electromagnetic wave equation for a homogeneous medium. **(06 Marks)**

8 a. What do you mean by depth of penetration? **(05 Marks)**

b. Explain electromagnetic waves propagation in perfect dielectric. **(07 Marks)**

c. Wet marshy soil is characterized by $\sigma = 10^{-2}$ s/m, $\varepsilon_r = 15$ and $\mu_r = 1$. At frequencies 60 Hz, 1 MHz, 100 MHz and 10 GHz, indicate whether soil be considered a conductor, or a dielectric. **(08 Marks)**

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EC44

Fourth Semester B.E. Degree Examination, Dec. 07 / Jan. 08
Field Theory

Time: 3 hrs. Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. State and explain Gauss' law. How are Gaussian surfaces chosen? **(06 Marks)**

b. Find the force on a 100 μC charge at (0, 0, 3) m if four like charges of 20 μC are located on the x and y axes at ± 4 m. **(08 Marks)**

c. A uniform line charge, infinite in extent, with $\rho_l = 20nC/m$, lies along the z axis. Find $\vec{E}$ at (6, 8, 3) m. **(06 Marks)**

2 a. Given the electric flux density $\vec{D} = 5\sin\theta \hat{a}_\theta + 5\sin\phi \hat{a}_\phi$, find the charge density at (0.5m, $\pi/4$, $\pi/4$) (Spherical coordinates). **(06 Marks)**

b. Find the work done in moving a point charge $Q = 5\mu C$ from origin to (2m, $\pi/4$, $\pi/2$) in spherical co-ordinates in the field

$$E = 5e^{-r/4}\hat{a}_r + \frac{10}{r\sin\theta}\hat{a}_\phi.$$ **(06 Marks)**

c. Given that the energy W_E in an electric field due to distributed charge density ρ_V throughout a volume V is given by

$$W_E = \frac{1}{2}\int_V \rho_V V dv$$

Show that an equivalent expression for the stored energy is

$$W_E = \frac{1}{2}\int_V \varepsilon E^2 dv$$ **(08 Marks)**

3 a. State and explain divergence theorem when applied to the electric flux density $\vec{D}$. **(05 Marks)**

b. There exists a spherical volume charge of radius a with uniform charge density ρ_V. Obtain electric field intensity $\vec{E}$, and sketch it as a function of radius r. Verify the divergence theorem for $r < a$ and $r > a$. **(15 Marks)**

4 a. Derive the Poisson's equation. **(05 Marks)**

b. Find the maximum torque on an orbiting charged particle if the charge is 1.602×10^{-19}C, the circular path has a radius of 0.5×10^{-10} m, the angular velocity is 4.0×10^{16} rad/s and the magnetic flux density $B = 0.4\times10^{03}T$. **(05 Marks)**

c. Find the potential function and the electric field intensity for the region between two concentric right circular cylinders, where V = 0 at r = 1 mm and V = 150 V at r = 20 mm, if $\varepsilon_r = 3.6$ (neglect fringing). Find the surface charge density on each cylinder. Determine the capacitance between the conducting cylinders per meter length. **(10 Marks)**

5 a. State and prove the uniqueness theorem. **(08 Marks)**

b. An infinitely long coaxial cable carrying current I in the inner conductor with internal radius a and current $-I$ in the outer conductor, with radii extending from $3a$ to $4a$. Sketch the variation of the magnetic field $\vec{H}$ as a function of radius r. **(12 Marks)**

6 a. State and explain the Lorentz force equation. **(06 Marks)**

b. A condutor of length 2.5 m located at z = 0, x = 4 m carries a current of 12 A in the $-\hat{a}_y$ direction. Find the uniform $\vec{B}$ in the region if the force on the conductor is 1.2×10^{-2} N in the direction $\frac{\left(-\hat{a}_x+\hat{a}_z\right)}{\sqrt{2}}$. **(08 Marks)**

c. A solenoid with $N_1=1000$, $r_1=1$ cm and $l_1=50$ cm is concentric within second coil of $N_2=2000$, $r_2=2$ cm and $l_2=50$ cm. Find the mutual inductance assuming free-space conditions. **(06 Marks)**

7 a. Derive the wave-equation for free space. **(10 Marks)**

b. Current I flows through a conductor of length L. Obtain the magnetic field $\vec{H}$, at the center of the loop when the conductor is made to form a circular loop. **(05 Marks)**

c. A radial magnetic field $\vec{H}=\frac{2.239\times10^6}{r}\cos\phi\,\hat{a}_r$ A/m exists in free space. Find the magnetic flux φ crossing the surface defined by $-\frac{\pi}{4}\le\phi\le\frac{\pi}{4}$, $0\le z\le1$ m. **(05 Marks)**

8 a. State and explain the Poynting's theorem. **(05 Marks)**

b. In free space $\vec{E}(z,t)=50\sin(\omega t-\beta z)\hat{a}_y$ (V/m). Find electric flux density $\vec{D}$, the magnetic flux density $\vec{B}$, the magnetic field $\vec{H}$, direction of propagation, speed of propagation, the average power crossing a circular area of radius 2.5 m in the plane Z = constant. **(15 Marks)**

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06EE44

Fourth Semester B.E. Degree Examination, Dec 08 / Jan 09
Field Theory

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. State and explain Gauss's law. **(06 Marks)**

b. The electric flux density in free space is given by $\hat{D} = y^2z^3\hat{x} + 2xyz^3\hat{y} + 3xy^2z^2\hat{z}$ pc/m^2. Find the total charge contained in an incremental sphere of radius 2 μm centered at A(3, 2, 1)m. **(06 Marks)**

c. Three point charges Q_1= -1 μC, Q_2 = -2μC and Q_3 = -3μC are placed at the corners of an equilateral triangle of side 1 m. Find the magnitude of the electric field intensity at the point bisecting the line joining Q_2 and Q_3. **(08 Marks)**

2 a. State and explain divergence theorem for electric flux density. **(06 Marks)**

b. Derive an expression for the energy expended in moving a point charge in an electric field. **(06 Marks)**

c. The potential field V is given by V = $2x^2y - 5z$. Calculate the electric field intensity at point P(-4, 3, 6)m. Also calculate the volume charge density that establishes the given potential field. **(08 Marks)**

3 a. Derive an expression relating convection current density, volume charge density and velocity of the charge element. **(06 Marks)**

b. Obtain the boundary conditions at the interface of two dielectrics. **(06 Marks)**

c. Using Laplace's equation, determine the distribution of potential and electric field intensity between two spherical conductors separated by a dielectric. The inner conductor is at potential V_0 while the outer conductor is grounded. **(08 Marks)**

4 a. Use Biot – Savart's law and obtain expression for the field intensity at any point on the axis of a plane circular current loop. **(08 Marks)**

b. State and explain Ampere's circuital law. Also write Ampere's circuital law in point forms. **(06 Marks)**

c. A conductor in the form of a regular polygon of 'n' sides is inscribed in a circle of radius 'r'. Find an expression for the field intensity at the centre of the circle. **(06 Marks)**

PART – B

5 a. A current element 10^{-4} $\hat{a}z$ Am. is located at (2,0, 0) and another current element $10^{-6}(\hat{x} - 2\hat{y} + 3\hat{z})$ Am. is located at (-2, 0, 0) both in free space. Find the force exerted on each current element by the other current element. **(08 Marks)**

b. An air cored toroid has a c-s area of 6cm^2, a mean radius of 15cm and is wound with 500 turns and carries a current of 4A. Find the magnetic field intensity at the mean radius. **(06 Marks)**

c. Derive differential form of continuity equation from Maxwell's equation. **(06 Marks)**

6 a. Write Maxwell's equation in point form and in integral form for time varying fields. **(06 Marks)**

b. Starting with Maxwell's equation from Faraday's law, show that the line integral of $\left(\hat{E}+\frac{\partial A}{\partial t}\right)$ around a closed path is zero, where A is magnetic vector potential. **(06 Marks)**

c. What is meant by displacement current? Show that for harmonically varying electric field, the conduction and displacement currents are in time phase quadrature. **(08 Marks)**

7 a. If the electric field intensity in free space is given by $\hat{E} = E_m \sin \alpha x \sin (wt - \beta z)\ \hat{y}$ V/m, find an expression for the magnetic field intensity $\hat{H}$. **(10 Marks)**

b. In a homogeneous, non conducting region where $\mu_r = 1$, find ϵ_r, ω and V if $\hat{E}$ and $\hat{H}$ fields are given by $\hat{E} = 30\pi e^{j}(wt - \frac{4y}{3})\hat{z}$ V/m and $\hat{H} = 1.0e^{j}(wt - \frac{4}{3}y)\hat{x}$ A/m respectively. **(10 Marks)**

8 a. Obtain the relation between electric field intensity $\hat{E}$ and magnetic field intensity $\hat{H}$ in a perfect dielectric medium. **(06 Marks)**

b. State and prove Poynting theorem. **(08 Marks)**

c. Define 'depth of penetration'. Show that depth of penetration of a wave in a conductor decreases with an increase in frequency. **(06 Marks)**

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06EE44

Fourth Semester B.E. Degree Examination, June-July 2009
Field Theory

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. State and explain experimental law of Coulomb. **(05 Marks)**

b. Identical point charges of 3μC are located at the four corners of the square of 5cm side, find the magnitude of force on any one charge. **(08 Marks)**

c. Using Gauss law, determine electric field intensity every where due to a hollow sphere of charge. **(07 Marks)**

2 a. Obtain an expression for the energy expanded in moving a point charge in an electric field. **(05 Marks)**

b. Potential is given by $V = 2(x+1)^2(y+2)^2(z+3)^2$ volts in free space. At a point P(2, –1, 4) calculate i) Potential ii) Electric field intensity iii) Flux density and iv) Volume charge density. **(08 Marks)**

c. Obtain boundary conditions for dielectric-dielectric boundary. **(07 Marks)**

3 a. Explain Poisson's equation & Laplace equation. **(05 Marks)**

b. Given the potential field $V = [Ar^4 + Br^{-4}] \sin 4\phi$ volts. Show that $\nabla^2 v = 0$, select A & B so that v = 100 volts and $|\vec{E}| = 500$ v/m at P(r = 1, $\phi = 22.5°$, z = 2). **(08 Marks)**

c. State and prove Uniqueness theorem. **(07 Marks)**

4 a. Using Biot Savart's law, obtain magnetic field intensity expression due to an infinite length conductor carrying current I. **(05 Marks)**

b. Derive the general expression for the field $\vec{B}$ at any point along the axis of a solenoid. **(08 Marks)**

c. Define vector magnetic potential. Prove that $A = \int_v \frac{\mu_0 J dv}{4\pi R}$. **(07 Marks)**

PART – B

5 a. Derive Lorentz force equation and mention the application of the solution. **(05 Marks)**

b. Derive an expression for the force on a differential current element placed in a magnetic field. Find the force per meter length between two long parallel wires separated by 10cm in air and carrying a current of 10A in the same direction. **(08 Marks)**

c. Derive differential form of continuity equation. **(07 Marks)**

6 a. What is the inconsistency of Ampere's law with the equation of continuity? Derive the modified form of Ampere's law of Maxwell. **(05 Marks)**

b. Given $\vec{E} = E_0 \sin(wt - \beta z)\vec{a}y$ v/m in free space. Find i) $\vec{D}$ ii) $\vec{B}$ iii) $\vec{H}$. Sketch $\vec{E}$ & $\vec{H}$ at t = 0. **(08 Marks)**

c. Write Maxwell's equation in point form and in integral form for time varying fields. **(07 Marks)**

7 a. Define wave equation. Derive the wave equation for $\vec{E}$ in a general medium. **(05 Marks)**

b. For an electromagnetic wave propagating in free space, prove that

i) $\frac{|\vec{E}|}{|\vec{H}|} = \eta$ ii) $\vec{E}$ & $\vec{H}$ are mutually perpendicular **(08 Marks)**

c. State and prove Poynting theorem. **(07 Marks)**

8 a. Define 'depth' of penetration'. Show that depth of penetration of a wave in a conductor decreases with an increase in frequency. **(05 Marks)**

b. Show that at any instant the magnetic and electric field in a reflected wave are out-of phase by 90°. **(08 Marks)**

c. Define Brewster's angle. Derive the necessary expression in terms of permittivity. **(07 Marks)**

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06EE44

Fourth Semester B.E. Degree Examination, Dec.09-Jan.10
Field Theory

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Given $D = [10r^2 + 5e^{-r}]\ \hat{a}_r\ {}^{c}/_{m^2}$. Find the following :

i) ρ_v as a function of r

ii) The total charge enclosed by a sphere of radius a,centered at the origin. **(08 Marks)**

b. Derive an expression for electric field intensity due to circular disc of charge density $\rho_s\ {}^{c}/_{m^2}$. **(05 Marks)**

c. Derive an expression for electric field intensity due to an infinite line charge of linear charge density ρ_L, using Gauss law. **(07 Marks)**

2 a. Prove that $E = -\nabla V$. **(04 Marks)**

b. Determine the work done in carrying a -2μc charge from $P_1(2,1,-1)$ to $P_2(8,2,-1)$ in the field $\vec{E} = Y\hat{a}_x + x\hat{a}_y\ {}^{V}/_{m}$, along the parabola $x = 2y^2$. **(08 Marks)**

c. With usual notations, derive boundary conditions at the boundary between a dielectric and a conductor in an electric field. **(08 Marks)**

3 a. Using Laplace equation, derive an expression for the capacitance of a concentric spherical capacitor. **(08 Marks)**

b. State and prove uniqueness theorem. **(07 Marks)**

c. If the field of a region of space is given by $\vec{E} = \hat{a}_z(5\cos z)$, is the region free of charge? **(05 Marks)**

4 a. Given the field $\vec{H} = 20\,r^2\,\hat{a}_\phi\ {}^{A}/_{m}$;

i) Determine the current density $\vec{J}$.

ii) Integrate $\vec{J}$ over the circular surface r = 1, $0 < \phi < 2\pi$ z= 0, to determine the total current passing through that surface in the $\hat{a}_z$ direction. **(08 Marks)**

b. Derive the expressions for scalar and vector magnetic potential. **(08 Marks)**

c. Prove that vector magnetic potential satisfies Poisson's equation. **(04 Marks)**

PART – B

5 a. Define self inductance and mutual inductance with suitable formulae. **(04 Marks)**

b. A solenoid with air core has 2000 turns and a length of 500mm. Core radius is 40mm. Find its inductance. Derive the formula used. **(08 Marks)**

c. For the square loop of wire in the z = 0 plane carrying 2mA in the field of an infinite filament on the Y-axis, as shown in Fig.Q5(c), calculate the total force on the loop.

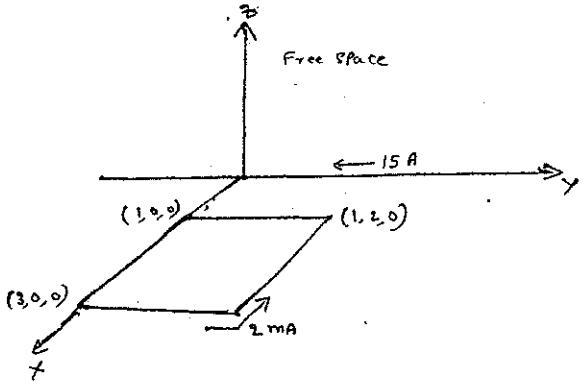

Fig.Q5(c) **(08 Marks)**

6 a. Starting from the concept of Faraday's law of electromagnetic induction, derive the Maxwell's equation, $\nabla \times E = -\frac{\partial B}{\partial t}$. **(06 Marks)**

b. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10^{-4}$ ℧/m and $\varepsilon_r = 81$. **(04 Marks)**

c. Explain the concept of retarded potentials. Derive the expressions for the same. **(10 Marks)**

7 a. A radio station transmits power radially around the spherical region. The desired electric field intensity at a distance of 10km from the station is 1 mv/m. Calculate the corresponding H, P and station power. **(06 Marks)**

b. State and prove Poynting theorem. **(06 Marks)**

c. For an electromagnetic wave, prove that $\alpha = \omega\sqrt{\frac{\mu\in}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\in}\right)^2}-1\right]^{1/2}$ and $\beta = \omega\sqrt{\frac{\mu\in}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\in}\right)^2}+1\right]^{1/2}$ where α = attenuation constant and β = phase constant. **(08 Marks)**

8 a. Define the terms :
i) Reflection coefficient and
ii) Transmission coefficient.
Also bring out the relation between them. **(08 Marks)**

b. Write short note on SWR. **(05 Marks)**

c. A uniform plane wave in air partially reflects from the surface of a material whose properties are unknown. Measurements of the electric field in the region in front of the interface yield 1.5m spacing between the maxima with the first maximum occurring 0.75m from the interface. A standing wave ratio of 5 is measured. Determine the intrinsic impedance of the unknown material. **(07 Marks)**

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