TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BEI, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX 503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary formulas are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. Transform the vector $\vec{A} = 4\hat{a}_x - 2\hat{a}_y - 4\hat{a}_z$ into spherical co-ordinates at a point P(x = -2, y = -3, z = 4). [5]
2. An infinite uniform line charge ρL = 2nC/m lies along the x-axis in free space, while point charges of 8nC each are located at (0, 0, 1) and (0, 0, -1). (a) Find $\vec{D}$ at (2, 3, -4). [6]
3. Define uniqueness theorem. Find the energy stored in free space for the region 2mm< r< 3mm, 0<θ<90°, 0<ϕ<90°, given the potential field V = : [2+6]

   a) $\frac{200}{r}$V and b) $\frac{300}{r^2}\cos\theta$V
4. Using the continuity equation elaborate the concept of Relaxation Time Constant (RTC) with necessary derivations. Let $\vec{J} = \frac{e^{-10^4 t}}{\rho^2}\hat{a}_\rho$ A/m² be the current density in a given region. At t = 10ms, calculate the amount of current passing through surface ρ = 2m, $0 \le z \le 3$m, $0 \le \phi \le 2\pi$. [4+4]
5. State and prove the Stoke's Theorem. Calculate the value of the vector current density: In cylindrical coordinates at P_B(1.5,90°,0.5) if $\vec{H} = \frac{2}{\rho}(\cos 0.2\,\phi)\,\hat{a}_\rho$. [5+3]
6. Define scalar magnetic potential. The region y<0 (region 1) is air and y>0 (region 2) has μ_r = 10. If there is a uniform magnetic field $\vec{H} = 5\hat{a}_x + 6\hat{a}_y + 7\hat{a}_z$ A/m in region 2, find $\vec{B}$ and $\vec{H}$ in region 2. [2+6]
7. List out the Maxwell equations phasor form for time varying case in free space. A conducting bar can slide freely over two conducting rails placed at x = 0 and x = 10cm. Calculate the induced voltage in the bar if the bar slides at a velocity $\vec{V} = 10a\hat{y}$ m/s and $\vec{B} = 3\hat{a}_z \text{mWb/m}^2$. [2+3]

8. A uniform plane wave in free space is given by $\vec{H}_S = (250\angle 30°)e^{-j350Z}\hat{a}_x V/m$. Determine phase constant, frequency of the wave, intrinsic impedance, $\vec{E}_S$ and the magnitude $\vec{H}$ of at $z = 25mm$ and $t = 4ps$. [1+2+1+2+2]

9. Within a certain region, $\varepsilon = 10^{-11} F/m$ and $\mu = 10^{-5} H/m$. If $B_x = 2\times10^{-4} \cos 10^5 t \sin 10^{-3} y$ T find: [3+3+2]

   a) Find $\vec{E}$
   b) Find the total magnetic flux passing through the surface $x = 0$, $0 < y < 40m$, $0 < z < 2m$ at $t = 1\ \mu s$
   c) Find the value of the closed line integral of $\vec{E}$ around the perimeter of the given surface.

10. A transmission line operating at 120MHz has $R = 20\Omega/m$, $L = 0.3\mu H/m$, $C = 63pF/m$ and $G = 4.2ms/m$. Find [3+3+2]

    a) Propagation coefficient (γ)
    b) Velocity of wave propagation on the line (v)
    c) Characteristic impedance (Z_o)

11. A rectangular waveguide has dimension a = 4cm and b = 2 cm. Determine the cut-off frequency and range of frequencies over with the guide will operate single mode. [6]

12. Write short notes on antenna and its types. [2]

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- ✓ *Assume that the* ***Bold Faced*** *letter represents a vector and* $\mathbf{a}_{subscript}$ represents a unit vector.

1. Find the vector that extends from A(-3,-4,6) to B(-5,2,-8) and express it in cylindrical coordinate system. [1+4]

2. A point charge of 12nC is located at the origin. Four uniform line charges are located in the x=0 plane as follow: 80nc/m at y=-1 and -5m, -50 nC/m at y=-2 and -4 m. Find the electric flux density **D** at P(0,-3,2). [7]

3. Let the region z<0 be composed of a uniform dielectric material for which ε_{R1}=3.2, while the region z>0 is characterized by ε_{R2}=2. Let $\mathbf{D}_1=-30\mathbf{a}_x+50\mathbf{a}_y+70\mathbf{a}_z$ nC/m^2 and find:- [7]

    a) $\mathbf{D}_{t1}$ (Tangential component of **D** in Region 1);
    b) Polarization ($\mathbf{P}_1$);
    c) $\mathbf{E}_{n2}$ (Normal component of **E** in Region 2)
    d) $\mathbf{E}_{t2}$ (Tangential component of **E** in Region 2)

4. Derive the Possion's and Laplace's equations. Assuming that the potential V in the cylindrical coordinate system is the function of 'r' only, solve the Laplace's equation by Integration Method an derive the expression for the capacitance of the Spherical Capacitor using the same solution of V. [2+5]

5. Derive the equation for magnetic field intensity in different regions due to a co-axial cable carrying a uniformly distributed dc current I in the inner conductor and –I in the outer conductor. [6]

6. Find the vector magnetic field intensity **H** in Cartesian coordinate at P(-1.5, -4, 3) caused by a current filament of 12A in the $\mathbf{a}_z$ direction on the z-axis and extending from z=-3 to z=3. [6]

7. Define Curl and give the physical interpretation of the Curl with a suitable example. [1+3]

8. A uniform plane wave in free space is propagating in the -$\mathbf{a}_y$ direction at a frequency of 5 MHz. If **E**=200 cos (ωt+βy) $\mathbf{a}_z$ V/m, write the expressions for electric and magnetic fields, i.e., $\mathbf{E}_s$ (x,y,z) and $\mathbf{H}_s$ (x, y, z) respectively in phasor forms. [3+5]

9. Derive an expression for Standing Wave Ratio (SWR) indicating where on the z-axis you'll get the maximum and minimum value of electric field intensity E. Assume that the boundary is at z=0, the region z<0 is a perfect dielectricand the region z>0 may be of any material. [8]

10. Find the amplitude of the displacement current density in an air space within a large power transformer where $\mathbf{H}=10^6 \cos(377t+1.2566 \times 10^{-6}z)\, \mathbf{a}_y$ A/m. [6]

11. A lossless 50-Ω line is 1.5λ long and is terminated with a pure resistance of 100Ω. The load voltage is $40\underline{/60^\circ}$V. Find: (a) the average power delivered to the load; (b) the magnitude of the minimum voltage on the line. [4+4]

12. What are the advantages and disadvantages of waveguides when you compare it with transmission lines? Explain the transverse electric (TE) and transverse magnetic (TM) modes used in rectangular waveguides. [3+3]

13. Give the definition of an antenna and explain the properties of any one type of antenna that you have studied during your electromagnetics course. [1+1]

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1. Given points A ($\rho = 5$, $\varphi = 70°$, $z = -3$) and B ($\rho = 2$, $\varphi = -30°$, $z = 1$), find: (a) a unit vector in cartesian coordinates at A directed toward B; (b) a unit vector in cylindrical coordinates at A directed toward B. [5]

2. Two uniform line charges, each 20 nC/m, are located at $y = 1$, $z = \pm 1$ m. Find the total electric flux leaving the surface of a sphere having a radius of 2 m, if it is centered at A (3, 1, 0). [6]

3. Derive Energy Density in electrostatic field. [7]

4. The conducting planes $2x + 3y = 12$ and $2x + 3y = 18$ are at potentials of 100 V and 0, respectively. Let $\varepsilon = \varepsilon_0$ and find: a) V at P (5, 2, 6); b) **E** at P(5,2,6). [7]

5. Let a filamentary current of 5 mA be directed from infinity to the origin on the positive z axis and then back out to infinity on the positive x axis. Find H at P (0, 1, 0). [8]

6. State Ampere's circuital law. Let the permittivity be 5 μH/m in region A where $x < 0$, and 20 μH/m in region B where $x > 0$. If there is a surface current density $\mathbf{K} = 150\mathbf{a}_y - 200\mathbf{a}_z$ A/m at $x = 0$, and if $\mathbf{H}_A = 300\mathbf{a}_x - 400\mathbf{a}_y + 500\mathbf{a}_z$ A/m, find: (a) $|\mathbf{H}_{LA}|$; (b) $|\mathbf{H}_{NA}|$; (c) $|\mathbf{H}_{LB}|$; (d) $|\mathbf{H}_{NB}|$. [10]

7. State and explain the Maxwell's equation in differential and integral form. Also define the displacement current and depth of penetration. [10]

8. Establish the relation for Helmholtz's equation for electromagnetic wave propagation. [5]

9. State and prove Poynting's theorem. [6]

10. A load $Z_l = 80 + j100\Omega$ is located at $z = 0$ on a lossless 50-Ω line. The operating frequency is 200 MHz and the wavelength on the line is 2 m. (a) If the line is 0.8 m in length, use the Smith chart to find the input impedance. (b) What is s? (c) What is the distance from the load to the nearest voltage maximum? [7]

11. An air-filled rectangular waveguide has dimensions a = 2 cm and b = 1 cm. Determine the range of frequencies over which the guide will operate single mode (TE_{10}). [3]

12. Write short notes on: [3x2]
    a) TE mode and TM mode
    b) Antenna Properties

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2074 Chaitra

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1. An uniform Electric Field Intensity in certain region is given by $\vec{E} = y\vec{a}_x - xy\vec{a}_y + z\vec{a}_z$. Transform this field vector into cylindrical co-ordinate at a point P(2, 45°, 3). [5]

2. A uniform line charge density of 150 μC/m lies at x = 2, z = -4 and a uniform sheet of charge equal to 25 nC/m² is placed at z = 5 plane. Find $\vec{D}$ at point (1, 2, 4) and convert it to the spherical coordinate system. [5+3]

3. Given the potential function $V = \frac{20\cos\theta}{r^2}$ V in free space and point P is located at r = 3m, θ = 60°, ϕ = 30° find: a) $\vec{E}_P$ b) $\frac{dV}{dN}$ at P c) unit normal vector at P d) ρ_v at P. [2+1+1+2]

4. Define Relaxation time Constant (RTC). Derive an expression for RTC. Given the vector current density $\vec{J} = 10\rho^2 z\vec{a}_\rho - 4\rho\cos^2\phi\,\vec{a}_\phi$ mA/m² . Find the current flowing outward through the circular band ρ = 3, 0 < ϕ < 2π, 2 < z < 2.8. [1+3+4]

5. Show that the vector magnetic potential can be defined in both the regions where $\vec{J}$ is equal or non-equal to zero. Use the concept of vector magnetic potential to derive the Magnetic Field Intensity due to an infinite current carrying filament carrying DC current I. [3+5]

6. State Stoke's theorem. Given the field $\vec{H} = \frac{1}{2}\cos\left(\frac{\phi}{2}\right)\vec{a}_\rho - \sin\left(\frac{\phi}{2}\right)\vec{a}_\phi$ A/m, evaluate both sides of Stroke's theorem for the path formed by the intersection of the cylinder ρ = 3 and the plane z = 2, and for the surface defined by ρ = 3, 0 ≤ z ≤ 2, and z = 0, 0 ≤ ρ ≤ 3. [1+7]

7. State Faradays Law. Correct the equation $\nabla\times\vec{H} = \vec{J}$ with necessary arguments and derivation for time varying field. [2+4]

8. Derive the expressions for reflection coefficient and transmission coefficient for the reflection of uniform waves at normal incidence. [8]

9. At 50 MHz, a lossy dielectric material is characterized by $\epsilon = 3.6\epsilon_0$, $\mu = 2.1\mu_0$ and $\sigma = 0.08$ S/m. If $\vec{E}_s = 6e^{-\gamma x}\,\vec{a}_z$ V/m, Compute: [2+2+4]

a) Propagation Constant
b) Wavelength
c) $\vec{H}_s$

10. State the condition for lossless transmission line. A lossless transmission line is 80 cm long and operates at a frequency of 600 MHZ. The line parameters are $L = 0.25\mu H/m$ and $C = 100$ pF/m. Find a) characteristics impedance b) phase constant c) phase velocity. [1+2+3+2]

11. Differentiate between Transmission line and waveguide. Consider a rectangular waveguide with $\epsilon_r = 2$, $\mu_r = 1$ with dimensions a = 1.07 cm, b = 0.43 cm find the cut off frequency for TM_{11} mode and the dominant mode. [1+4]

12. Write short notes on antenna and its parameters. [2]

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2075 Ashwin

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1. Expres in cartesian components: (a) the vector at A($\rho = 4$, $\Phi = 40°$, $z = -2$) that extends to B($\rho = 5$, $\Phi = -110°$, $z = 2$); (b) a unit vector at B directed toward A. [3+2]

2. Derive an Electric Field Intensity ($\vec{E}$) in between the two co-axial cylindrical conductors, the inner of radius 'a' and outer of radius 'b', each infinite in extent and assuming a surface charge density ρ_s on the outer surface of the inner conductor. An infinite uniform line charge $\rho_L = 2$ nC/m lies along the x-axis in free space, while the point charge of 8nC each are located at (0, 0, 1). Find $\vec{E}$ at (2, 3, -4) [4+4]

3. Derive the integral and point forms of continuity equation. In a certain region, $\vec{j} = 3r^2 \cos\theta\, \vec{a}_r - r^2 \sin\theta\, \vec{a}_\theta\ A/m^2$. Find the current crossing the surface defined by $\theta = 30°, 0 < \phi < 2\pi, 0 < r < 2$. [5+3]

4. Given the field, $\vec{D} = \frac{5\sin(\theta)\cos(\phi)}{r} a_r C/m^2$, find: (a) the volume charge density; (b) the total charge contained in the region r < 2 m; (c) the value of D at the surface r = 2. [2+2+2]

5. Differentiate between scalar and vector magnetic potential. Derive the expression for magnetic boundary conditions. [3+5]

6. State Stroke's theorem. Evaluate both sides of Stroke's theorem for the field $\vec{G} = 10\sin\theta\, \hat{a}_\phi$ and the surface $r = 3, 0 \le \theta \le 2\pi, 0 \le \phi \le 90°$. Let the surface have the $\hat{a}_r$ direction. [1+7]

7. Find the capacitance of a spherical capacitor using Laplace's equation. [6]

8. Write point form of all the Maxwell's Equations in phasor domain, for perfect dielectric material. Use these equations to derive the magnetic field component of a uniform plan wave travelling in the perfect dielectric medium. [2+6]

9. Let $\vec{E}(z,t) = 1800\cos(10^7\pi t - \beta z)\, \vec{a}_x$ V/m and $\vec{H}(z,t) = 3.8\cos(10^7\pi t - \beta z)\, \vec{a}_y$ A/m represents a uniform plane wave propagating at a velocity of 1.4×10^8 m/s in perfect dielectic. Find a) β b) λ c) η d) μ_r e) ε_r . [2+1+2+2+1]

10. The velocity of propagation in a lossless transmission line 2.5×10^8 m/s. If the capacitance of the line is 30 pf/m, find: [2+2+2+2]

a) Inductance of the line
b) Characteristic impedance
c) Phase constant at 100 MHZ
d) Reflection coefficient if the line is terminated with a resistive load of 50Ω

11. What are the advantages of waveguides over transmission lines? A rectangular waveguide has a cross-section of 2.5 cm × 1.2 cm. Find the cut-off frequencies at dominant mode and TE (1,1) [1+4]

12. Write short notes on: Antenna properties [2]

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1. Express a scalar potential field $V = x^2 + 2y^2 + 3z^2$ in spherical coordinates. Find value of V at a point P(2,60°,90°). [3+2]

2. Derive the expression of Electric field intensity due to a line charge using Gauss Law. Find Electric flux density at point P(5,4,3) due to a uniform line charge of 2 nC/m at x = 5, y =3, point charge 12 nC at Q(2,0,6) and uniform surface charge density of 0.2 nC/m^2 at x = 2. [4+4]

3. State the physical significance of divergence. Derive the Divergence theorem. Given the potential $V = \frac{10}{r^2}\sin\theta\cos\phi$; find the electric flux density $\vec{D}$ at $\left(2, \frac{\pi}{2}, 0\right)$. [2+2+3]

4. Derive Laplace's equation. Find the capacitance of a co-axial cable using Laplace's equation. [1+5]

5. State Ampere's circuital law. By using Biot Savart's law, derive an expression for magnetic field intensity $\left(\vec{H}\right)$ due to an infinite length filament carrying a direct current I. [2+6]

6. Flux density at medium with $\mu_1 = 15$ is $\vec{B}_1 = 1.2a_x + 8a_y + 4a_z T$. Find $\vec{B}, \vec{H}$ and the angles between the field vectors and tangent to the interface at second medium, if second medium has $\mu_2 = 1$, and interface plane is z = 0. [3+2+3]

7. State and derive the expression of motional emf (electromotive force). Consider two parallel conductors placed at x =0 and x = 5 cm in a magnetic field $\vec{B} = 6\vec{a}_z\, mWb/m^2$. A high resistance voltmeter is connected at one end and a conducting bar is sliding at other end with velocity $\vec{v} = 18\vec{a}_y\, m/s$. Calculate the induced voltage and show the polarity of induced voltage across the voltmeter. [1+3+3]

8. What is standing wave? Derive the equation of Electric field and Magnetic field and SWR of standing wave? [1+7]

9. An EM wave travels in free space with the electric field component $\vec{E} = \left(15\vec{a}_y - 5\vec{a}_z\right)$ $\cos(\omega t - 3y + 5z)$ V/m. Find (a) ω and λ (b) the magnetic field component. [2+2+3]

10. A 50Ω lossless transmission line is 30 m long and is terminated with a load $Z_L = 60 + j40\Omega$. The operating frequency is 20 MHz and velocity on the line is 2.5×10^8 m/s. Find [2+2+4]

    i) Reflection coefficient
    ii) Standing wave ratio
    iii) Input impedance

11. Explain TE and TM modes? Consider a rectangular waveguide with εr = 2.25 and $\mu_r = 1$ with dimensions a = 1.07, b = 0.43. Find the cut-off frequency for TM_{11} mode and dominant mode. [2+4]

12. Write short notes on antenna and its type. [2]

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1. Convert the vector $\vec{F} = F_x \vec{a}_x + F_y \vec{a}_y + F_z \vec{a}_z$ to both spherical coordinate system. [5]
2. Find the electric field intensity in all three regions due to an infinite sheet parallel plate capacitor having surface charge density ρ_s c/m^2 and $-\rho_s$ c/m^2 and placed at y = 0 and y = b respectively. Let a uniform line charge density, 3 nC/m, at y = 3; uniform surface charge density, 0.2 nC/m^2 at x = 2. Find $\vec{E}$ at the origin. [4+4]
3. What is dipole? Derive the equation for potential and electric field due to dipole at a distant point P. [1+6]
4. Derive Poisson's equation. By solving Laplace's equation, find the capacitance of a parallel plate capacitor with potential difference between the plates equals V_0. [1+5]
5. Verify stoke's theorem for the field $\vec{H} = \left(\frac{3r^2}{\sin\theta}\right)\vec{a}_\theta + 54r\cos\theta\, \vec{a}_\phi$ A/m in free space for the conical surface defined by $\theta = 20°$, $0 \le \phi \le 2\pi$, $0 \le r \le 5$. Let the positive direction of $\vec{ds}$ be $\vec{a}_\theta$. [8]
6. Consider a boundary at z = 0 for which $\vec{B}_1 = 2\vec{a}_x - 3\vec{a}_y + \vec{a}_z$ mT, μ_1 = 4 μH/m (z > 0), μ_2 = 7 μH/m (z < 0) and $\vec{K} = 80\vec{a}_x$ A/m at z = 0. Find $\vec{B}_2$ [8]
7. Explain how Ampere's law conflict with continuity equation and how it is corrected? Derive conduction and displacement current in a capacitor. [4+3]
8. Derive the expression for electric and magnetic fields for a uniform plane wave propagating in a perfect dielectric medium. [5+3]
9. A 9.4 GHz uniform plane wave is propagating in a medium with $\epsilon_r = 2.25$ an $\mu_r = 1$. If the magnetic field intensity is 7 mA/m and the material is loss less, find [1+1+1+2+2]
   i) Velocity of propagation
   ii) The wave length
   iii) Phase constant
   iv) Intrinsic impedance
   v) Magnitude of electric field intensity

10. A lossless line having an air dielectric has a characteristics impedance of 400 Ω. The line is operating at 200 MHz and $z_{in} = 200 - j200\,\Omega$. Find (a) SWR (b) Z_L, if the line is 1 m long; (c) the distance from the load to the nearest voltage maximum. [2+4+2]

11. Differentiate between transmission line and waveguide. A rectangular waveguide having cross-section of 2 cm× 1 cm is filled with a lossless medium characterized by $\varepsilon = 4\varepsilon_0$ and $\mu_r = 1$. Calculate the cut-off frequency of the dominant mode. [4+2]

12. Write short notes on antenna and its properties. [2]

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DIVERGENCE

CARTESIAN $\nabla\cdot\bar{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$

CYLINDRICAL $\nabla\cdot\bar{D} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho D_\rho) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$

SPHERICAL $\nabla\cdot\bar{D} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 D_r) + \frac{1}{r\sin\theta}\frac{\partial(\sin\theta\, D_\theta)}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial D_\phi}{\partial \phi}$

GRADIENT

CARTESIAN $\nabla V = \frac{\partial V}{\partial x}\hat{a}_x + \frac{\partial V}{\partial y}\hat{a}_y + \frac{\partial V}{\partial z}\hat{a}_z$

CYLINDRICAL $\nabla V = \frac{\partial V}{\partial \rho}\hat{a}_\rho + \frac{1}{\rho}\frac{\partial V}{\partial \phi}\hat{a}_\phi + \frac{\partial V}{\partial z}\hat{a}_z$

SPHERICAL $\nabla V = \frac{\partial V}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\hat{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\hat{a}_\phi$

CURL

CARTESIAN $\nabla\times\bar{H} = \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)\hat{a}_x + \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right)\hat{a}_y + \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right)\hat{a}_z$

CYLINDRICAL $\nabla\times\bar{H} = \left(\frac{1}{\rho}\frac{\partial H_z}{\partial \phi} - \frac{\partial H_\phi}{\partial z}\right)\hat{a}_\rho + \left(\frac{\partial H_\rho}{\partial z} - \frac{\partial H_z}{\partial \rho}\right)\hat{a}_\phi + \frac{1}{\rho}\left(\frac{\partial(\rho H_\phi)}{\partial \rho} - \frac{\partial H_\rho}{\partial \phi}\right)\hat{a}_z$

SPHERICAL $\nabla\times\bar{H} = \frac{1}{r\sin\theta}\left(\frac{\partial(H_\phi\sin\theta)}{\partial \theta} - \frac{\partial H_\theta}{\partial \phi}\right)\hat{a}_r + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial H_r}{\partial \phi} - \frac{\partial(rH_\phi)}{\partial r}\right)\hat{a}_\theta$

$+\frac{1}{r}\left(\frac{\partial(rH_\theta)}{\partial r} - \frac{\partial H_r}{\partial \theta}\right)\hat{a}_\phi$

LAPLACIAN

CARTESIAN $\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}$

CYLINDRICAL $\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho\frac{\partial V}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2}$

SPHERICAL $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial \phi^2}$

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INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ $\vec{A}$ *represent a vector and* $\hat{a}_{subscript}$ *and* $\vec{a}_{subscript}$ *denotes a unit vector along the direction given by the subscript.*
- ✓ *Assume suitable data if necessary.*

1. Express the uniform vector field $\vec{F} = 5\vec{a}_x$ in (a) cylindrical components (b) spherical components. [2+3]
2. Derive the expression for the electric field intensity due to an infinitely long line charge with uniform charge density ρ_L by using Gauss's law. A uniform line charge density of 20 nC/m is located at $y = 3$ and $z = 5$. Find $\vec{E}$ at P(5,6,1) [4+4]
3. Derive an expression to calculate the potential due to a dipole in terms of the dipole moment $(\vec{p})$. A dipole for which $\vec{p} = 3\vec{a}_x - 5\vec{a}_y + 10\vec{a}_z$ nC.m is located at the point (1,2,-4). Find $\vec{E}$ at P. [4+4]
4. Assuming that the potential V in the cylindrical coordinate system is function of ρ only, solve the Lapplace's equation and derive the expression for the capacitance of coaxial capacitor of length L using the same solution of V. Assume the inner conductor of radius a is at potential V_0 with respect to the conductor of radius b. [6]
5. State and derive expression for Stoke's theorem. Evaluate the closed line integral of $\vec{H}$ from $P_1(5,4,1)$ to $P_2(5,6,1)$ to $P_3(0,6,1)$ to $P_4(0,4,1)$ to P_1 using straight line segments, if $\vec{H} = 0.1y^3\,\vec{a}_x + 0.4x\,\vec{a}_z$ A/m. [1+3+4]
6. Define scalar magnetic potential and show that it satisfies the Laplace's equation. Given the vector magnetic potential $\vec{A} = -(\rho^2/4)\hat{a}_z$ Wb/m, calculate the total magnetic flux crossing the surface $\phi = \pi/2$, $1 \le \rho \le 2$ m and $0 \le z \le 5$ m. [1+2+5]
7. How does $\nabla \times \vec{H} = \vec{J}$ conflict with continuity equation in time varying fields. How is this conflict rectified in such fields? [2+3]
8. Derive the expression for electric and magnetic fields for a uniform plane wave propagating in a perfect dielectric space. [5+3]
9. A lossless dielectric material has $\sigma = 0, \mu_r = 1, \varepsilon_r = 4$. An electromagnetic wave has magnetic field expressed as $\vec{H} = -0.1\cos(\omega t - z)\vec{a}_x + 0.5\sin\cos(\omega t - z)\vec{a}_y$ A/m. Find: [2+2+4]
   a) Angular frequency (ω)
   b) Wave impedance (η)
   c) $\vec{E}$

10. Consider a two-wire 40 Ω line ($Z_0 = 40\Omega$) connecting the source of 80 V, 400 kHz with series resistance 10 Ω to the load of $Z_L = 60\Omega$. The line is 75 m long and the velocity on the line is 2.5×10^8 m/s. Find the voltage $V_{in,s}$ at input end and $V_{L,s}$ at output end of the transmission line. [8]

11. Why does a hollow rectangular waveguide not support TEM mode? A rectangular air-filled waveguide has a cross-section of 45×90 mm. Find the cut-off frequencies of the first four propagating modes. [2+4]

12. Write short notes on antenna and its types. [2]

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DIVERGENCE

CARTESIAN $\nabla\cdot\vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$

CYLINDRICAL $\nabla\cdot\vec{D} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial\phi} + \frac{\partial D_z}{\partial z}$

SPHERICAL $\nabla\cdot\vec{D} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 D_r) + \frac{1}{r\sin\theta}\frac{\partial(\sin\theta D_\theta)}{\partial\theta} + \frac{1}{r\sin\theta}\frac{\partial D_\phi}{\partial\phi}$

GRADIENT

CARTESIAN $\nabla V = \frac{\partial V}{\partial x}\hat{a}_x + \frac{\partial V}{\partial y}\hat{a}_y + \frac{\partial V}{\partial z}\hat{a}_z$

CYLINDRICAL $\nabla V = \frac{\partial V}{\partial\rho}\hat{a}_\rho + \frac{1}{\rho}\frac{\partial V}{\partial\phi}\hat{a}_\phi + \frac{\partial V}{\partial z}\hat{a}_z$

SPHERICAL $\nabla V = \frac{\partial V}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial V}{\partial\theta}\hat{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial\phi}\hat{a}_\phi$

CURL

CARTESIAN $\nabla\times\vec{H} = \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)\hat{a}_x + \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right)\hat{a}_y + \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right)\hat{a}_z$

CYLINDRICAL $\nabla\times\vec{H} = \left(\frac{1}{\rho}\frac{\partial H_z}{\partial\phi} - \frac{\partial H_\phi}{\partial z}\right)\hat{a}_\rho + \left(\frac{\partial H_\rho}{\partial z} - \frac{\partial H_z}{\partial\rho}\right)\hat{a}_\phi + \frac{1}{\rho}\left(\frac{\partial(\rho H_\phi)}{\partial\rho} - \frac{\partial H_\rho}{\partial\phi}\right)\hat{a}_z$

SPHERICAL $\nabla\times\vec{H} = \frac{1}{r\sin\theta}\left(\frac{\partial(H_\phi\sin\theta)}{\partial\theta} - \frac{\partial H_\theta}{\partial\phi}\right)\hat{a}_r + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial H_r}{\partial\phi} - \frac{\partial(rH_\phi)}{\partial r}\right)\hat{a}_\theta$

$$+\frac{1}{r}\left(\frac{\partial(rH_\theta)}{\partial r} - \frac{\partial H_r}{\partial\theta}\right)\hat{a}_\phi$$

LAPLACIAN

CARTESIAN $\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}$

CYLINDRICAL $\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial V}{\partial\rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 V}{\partial\phi^2} + \frac{\partial^2 V}{\partial z^2}$

SPHERICAL $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial\phi^2}$

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TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2073 Shrawan

Exam.	**New Back (2066 & Later Batch)**		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *$\vec{A}$ represent a vector and $\hat{a}_{\text{subscript}}$ and $\vec{a}_{\text{subscript}}$ denotes a unit vector along the direction given by the subscript.*
- ✓ *Assume suitable data if necessary.*

1. Define a vector field. A field vector is given by an expression $\vec{A} = \frac{1}{\sqrt{x^2+y^2+z^2}}\left(X\vec{a}_x + y\vec{a}_y + z\vec{a}_z\right)$, transform this vector in cylindrical coordinate system at point (2, 30°, 6) [2+3]

2. Given the flux density $\vec{D} = (2\cos\theta/r^3)\vec{a}_r + (\sin\theta/r^3)\vec{a}_\theta\ C/m^2$, evaluate both sides of the divergence theorem for the region defined by $1<r<2, 0<\theta<\frac{\pi}{2}, 0<\phi<\frac{\pi}{2}$. [8]

3. Define electric dipole and polarization. The region $z<0$ contains a dielectric material for which $\varepsilon_{r1} = 2.5$ while the region $z > 0$ is characterized by $\varepsilon_{r2} = 4$. Let $\vec{E}_1 = -30\hat{a}_x + 50\hat{a}_y + 70\hat{a}_z$ V/m. Find: (a) $\vec{E}_2$ (b) $\vec{D}_2$ (c) polarization in region 2 $\left(\vec{P}_2\right)$. [2+2+2+1+1]

4. State the uniqueness theorem and prove this theorem for Laplace's equation. [1+5]

5. A current density in certain region is given as: $\vec{J} = 20\sin\theta\cos\phi\,\vec{a}_r + \frac{1}{r}\vec{a}_\phi\ A/m^2$, Find: [5+3]

   i) The average value of J_r over the surface $r=1, 0<\theta<\pi/2, 0<\phi<\pi/2$

   ii) $\frac{\delta\rho_v}{\partial t}$

6. Show that $\nabla\times\vec{E}=0$ for static electric field. The region y<0 (Region 1) is air and y>0 (Region 2) has μ_r = 10. If there is a uniform magnetic field $\vec{H} = 5\vec{a}_x + 6\vec{a}_y + 7\vec{a}_z$ A/m in region 1, find $\vec{B}$ and $\vec{H}$ in region 2. [2+3+3]

7. Find the amplitude of the displacement current density in a metallic conductor at 60 Hz, if $\varepsilon = \varepsilon_0, \mu = \mu_0, \sigma = 5.8\times10^7$ S/m, and $\vec{J} = \sin(377t - 117.1z)\vec{a}_x$ MA/m^2. [5]

8. Explain the phenomena when a plane wave is incident normally on the interface between two different Medias. Derive the expression for reflection and transmission coefficient. [8]

9. A uniform plane wave in non-magnetic medium has $\vec{E} = 50\cos(10^8 t + 2z)\hat{a}_y \ V/m$. Find:

   i) The direction of propagation
   ii) Phase constant β, wavelength λ, velocity v_p, relative permittivity ε_r, intrinsic impedance η
   iii) $\vec{H}$ [1+5+2]

10. Determine the primary constants (R, L, C and G) on the transmission line when the measurement on the line at 1 KHz gave the following results: $z_0 = 710\angle{-16°}$, $\alpha = 0.01$ neper/m and $\beta = 0.035$ rad/m. [8]

11. Explain the modes supported by a rectangular waveguide. Calculate the cut off frequencies of the first four propagating modes for an air filled copper waveguide with dimension $a = 2.5\,cm$, $b = 1.2$ cm. [2+4]

12. Write short notes on antenna and its types. [2]

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INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetic (EX503)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt* ***All*** *questions.*
- ✓ *The figures in the margin indicate* ***Full Marks.***
- ✓ ***Necessary formula sheet is attached herewith.***
- ✓ $\overrightarrow{a_{subscript}}$ *denote a unit vector along the direction given by the subscript.*
- ✓ *Assume suitable data if necessary.*

1. Transform the vector $4\vec{a}_x - 2\vec{a}_y - 4\vec{a}_z$ into spherical coordinates at point P(-2,-3,4) [5]

2. State and write the mathematical equation of Gauss Law. Using the same law, derive an expression for electric field intensity $(\vec{E})$ in between the two co-axial cylindrical conductors having inner radius 'a' and outer radius 'b', each infinite in extent and assuming a surface charge density ρ_s on the outer surface of the inner conductor. [1+6]

3. State the physical significance of potential gradient. Assuming that the potential V in the spherical coordinate system is a function of r only, solve the Laplacian equation and derive the expression for the capacitance of a spherical capacitor using the same solution of V. [2+6]

4. Within the cylinder $\rho = 2$, $0 < z < 1$ the potential given by: $V = 100+50\rho+150\rho\sin\phi V$ find:[2+1+2+1]

   a) Electric Field Intensity $(\vec{E})$ at P (1, 60°, 0.5) in free space

   b) Potential Gradient $\left(\frac{dV}{dN}\right)$

   c) Volume Charge Density (ρ_v) at P(1,60°,0.5) in free space

   d) How much charge lies within the cylinder?

5. State the physical significance of Curl. Evaluate both sides of stokes theorem for the field $\vec{A} = 6xy\ \vec{a}_x - 3y^2\vec{a}_y\ A/m$ and the rectangular path around the region; $2 \le x \le 5$, $-1 \le y \le 1$, $z = 0$. Let the positive direction of $\vec{ds}$ be $\vec{a}_z$. [2+6]

6. Explain the physical significance of the equation $\oint_s \vec{B}.\vec{ds} = 0$. Given the vector magnetic potential $\vec{A} = \rho^2/8\ \vec{a}_z\ Wb/m$. Calculate the total magnetic flux crossing the surface $\phi = \pi/4$, $1 \le \rho \le 3m$, $0 \le z \le 5m$. [2+6]

7. Explain motional emf and transformer emf with necessary mathematical derivations. A straight conductor of 0.2m lies along x-axis with one end at the origin. If this conductor is subjected to the magnetic flux density $\vec{B} = 0.08\vec{a}_y$ T and velocity $v = 2.5 \sin 10^3 t \vec{a}_z$ m/s. Calculate the emf induced in the conductor. [6+2]

8. Define Transverse Electromagnetic (TEM) wave. Derive an expression electric field for a uniform plane wave propagating in a perfect dielectric media. [7+1]

9. A uniform plane wave in free space at a frequency of 12 MHz is given by $\vec{E} = 200\cos(\omega t + 120x + 30°)\vec{a}_y$ V/m, find (a) $|E_{max}|$ (b) $\vec{H}$ at x = 40mm and t = 340ps. [3+3]

10. A lossless transmission line with $Z_0 = 50\Omega$ has a length of 0.4λ. The operating frequency is 300MHz and it is terminated with a load $Z_L = 40+j30\Omega$. Find: [2+2+4]

    a) Reflection coefficient (Γ)
    b) Standing wave ratio on the line (SWR)
    c) Input impedance (Z_{in})

11. Explain Transverse Electric Mode and Transverse Magnetic Mode of a waveguide. [2+2]

12. Write short notes on: [2×2]

    a) Skin depth
    b) Antenna and its types

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ ***Necessary formula sheet is attached herewith.***
- ✓ $\overrightarrow{a_{subscript}}$ *denote a unit vector along the direction given by the subscript.*
- ✓ *Assume suitable data if necessary.*

1. Transform $\vec{A} = 10\vec{a}_x - 8\vec{a}_y + 6\vec{a}_z$; at point p(10,-8,6) to cylindrical coordinate system. [5]
2. A line charge of 8nC/m is located at x = -1, y = 2, a point charge of 6mC at y = -4 and a surface charge of 30 pC/m^2 at z = 0. If the potential at origin is 100V, find the potential at P (4,1,3). [7]
3. Explain the Continuity equation. The current density in certain region is approximated by $\vec{J} = \left(\frac{0.1}{r}\right) e^{-10^6 t}\, \vec{a}_r\, A/m^2$ in spherical coordinates. (a) How much current is crossing the surface r = 50cm at t = 1μS? (b) Find $\rho_v(r,t)$ assuming that $\rho_v \to 0$ as $t \to \infty$. [2+6]
4. Find the equation for Energy Density in the electrostatic field. [6]
5. Differentiate between scalar and vector magnetic potential. Derive an expression for the magnetic field intensity $(\vec{H})$ at a point due to an infinite filament carrying a direct current I, placed on z-axis using ampere's circuital law. [2+6]
6. State and prove Stoke's theorem. Given $\vec{H} = 10\sin\theta\, \vec{a}_r$ in free space. Find the current in $\vec{a}_r$ direction having $r = 3, 0 \le \theta \le 90°, 0 \le \phi \le 90°$. [3+5]
7. Within a certain region, $\varepsilon = 10^{-11}$ F/m and $\mu = 10^{-5}$ H/m.

   If $\vec{B}_x = 2\times10^{-4}\cos 10^5 t \sin 10^{-3} y\, \vec{a}_x$ T: (a) Use $\nabla \times \vec{H} = \varepsilon \frac{\partial \vec{E}}{\partial t}$ to find $\vec{E}$; (b) Find the total magnetic flux passing through the surface x = 0, $0 \le y \le 40$m, $0 \le z \le 2$m, at t = 1μS. [4+4]
8. Derive an expression for standing wave ratio of uniform plane wave in terms of reflection coefficient. Find the reflection coefficient for the interface between air and fresh water ($\epsilon = 81\epsilon_0, \sigma \cong 0$), in case of normal incidence. [5+3]

9. The magnetic field intensity $\left(\vec{H}\right)$ in free space is given as,

$\vec{H}(x,t) = 10\cos(10^8 t + \beta x)\vec{a}_y \ A/m$ find: [2+1+3]

a) Phase constant (β)
b) Wavelength
c) $\left|\vec{E}(x,t)\right|$ at P (0.1,0.2,0.3) at $t = 1nS$

10. A 300 Ω transmission line is lossless, 0.25λ long, and is terminated in $Z_L = 500\ \Omega$. The line has a generator with $90\ \angle 0°V$ in series with 100 Ω connected to the input. Find (a) the load voltage (b) voltage at the midpoint of the line. [4+4]

11. Determine the cut-off frequency for an air filled rectangular waveguide with a = 2.5 cm and b = 1.25 cm for TE_{11} mode. [4]

12. Write short notes on: [2+2]

a) Loss tangent

b) Antenna types and properties

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INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics (EX503)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Necessary formulas are attached herewith.*
- ✓ *Assume suitable data if necessary.*
- √ Assume that the **Bold Faced** letter represents a vector and $\mathbf{a}_{subscipt}$ represents a unit vector.

(1) Express the vector field, $\mathbf{G} = (x^2 + y^2)^{-1}(x\mathbf{a}_x + y\mathbf{a}_y)$ in cylindrical components and cylindrical variables. [5]

(2) Find **D** at the point (-3, 4, 2) if the following charge distributions are present in free space: ~~point charge, 12 nC, at P (2, 0, 6);~~ uniform line charge density, 3 nC/m, at x = -2, y = 3; uniform surface charge density, 0.2 nC/m^2 at x = 2. [7]

(3) Two uniform line charges, 8 nC/m each, are located at x = 1, z = 2, and at x = -1, y = 2 in free space. If the potential at the origin is 100V, find V at P (4, 1, 3). [7]

(4) State the Uniqueness theorem and prove that the solution of Poisson's equation is unique. [1+6]

(5) Write the equation of the Vector Magnetic Potential in differential form. Using the same equation, derive the equation for magnetic field intensity at a point due to an infinite filament carrying a uniformly distributed dc current I. [1+5]

(6) Calculate the value of the vector current density: (a) in cylindrical coordinates at P_1 (ρ=1.5, ϕ=90°, z=0.5) if $\mathbf{H} = \frac{2}{\rho}(\cos 0.2\phi)\ \mathbf{a}_\rho$. [3+3]

(b) in spherical coordinates at P_2 (r=2, θ=30°, ϕ=20°) if $\mathbf{H} = \frac{1}{\sin\theta}\ \mathbf{a}_\theta$.

(7) State and derive the Stoke's theorem. [1+3]

(8) What is an input intrinsic impedance? Derive an expression for the input intrinsic impedance using the concept of reflection of uniform plane waves. [2+6]

(9) The electric field amplitude of a uniform plane wave propagating in the free space in $\mathbf{a}_z$ direction is 250 V/m. If $\mathbf{E} = E_x \mathbf{a}_x$ and ω = 1.00 Mrad/s, find: (a) the frequency; (b) the wavelength; (c) the period; (d) the amplitude of H. [2+2+1+3]

(10) Find the amplitude of the displacement current density inside a typical metallic conductor where f = 1 kHz, Conductivity $\sigma = 5 \times 10^7$ mho/m, dielectric constant $\varepsilon_R = 1$; and the conduction current density $\mathbf{J} = 10^7 \sin(6283\, t - 444\, z)\, \mathbf{a}_x$ A/m^2. [6]

(11) A 50-Ω lossless line has a length of 0.4λ. The operating frequency is 300 MHz. A load $Z_L = 40 + j30\ \Omega$ is connected at z = 0, and the Thevenin equivalent source at z = -l is $12\angle 0^\circ$ in series with $Z_{Th} = 50 + j0\ \Omega$. Find: (a) The Reflection Coefficient Γ (b) The Voltage Standing Wave Ratio (VSWR) and (c) The input Impedance Z_{in}. [2+2+4]

(12) Explain why is it not possible to use waveguides at lower frequencies? Explain the transverse electric (TE) and transverse magnetic (TM) modes used in rectangular waveguides. [2+4]

(13) Give the definition of an antenna. Explain the properties of any one type of antenna that you have studied during your electromagnetics course. [1+1]

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26 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2070 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *__Necessary formula are attached herewith.__*
- ✓ *Assume suitable data if necessary.*

1. Transform the Vector $\vec{A} = y\vec{a}_x + x\vec{a}_y + z\vec{a}_z$ into cylindrical co-ordinates at a point p(2,45°,5) [5]
2. Along the z-axis there is a uniform line of charge with $\rho_L = 4\pi$ Cm^{-1} and in the x = 1 plane there is a surface charge with $\rho_s = 20$ Cm^{-2}. Find the Electric Flux Density at (0.5, 0, 0) [6]
3. Define Uniqueness theorem. Assuming that the potential V in the cylindrical coordinate system is the function of 'ρ' only, solve the Laplacian Equation by integration method and derive the expression for the Capacitance of the co-axial capacitor using the same solution of V. [2+5]
4. Define Electric Dipole and Polarization. Consider the region y < 0 be composed of a uniform dielectric material for which the relative permittivity (ε_r) is 3.2 while the region y > 0 is characterized by $\varepsilon_r = 2$. Let the flux density in region 1 be [2+3+3]

   $\vec{D}_1 = -30\vec{a}_x + 50\vec{a}_y + 70\vec{a}_z \, nC/m^2$.

   Find:
   a) Magnitude of Flux density and Electric fields intensity at region 2.
   b) Polarization $(\vec{P})$ in region 1 and region 2
5. State Ampere's circuital law and stoke's theorem. Derive an expression for magnetic field intensity $(\vec{H})$ due to infinite current carrying filament using Biot Savart's Law. [1+2+5]
6. Differentiate between scalar and vector magnetic potential. The magnetic field intensity in a certain region of space is given as $\vec{H} = (2\rho + z)\vec{a}_\rho + \frac{2}{z}\vec{a}_z$ A/m. Find the total current passing through the surface $\rho = 2$, $\pi/4 < \varphi < \pi/2$, $3 < z < 5$, in the $\vec{a}_\rho$ direction. [3+5]
7. State Faraday's law and correct the equation $\nabla \times \vec{E} = 0$ for time varying field with necessary derivation. Also modify the equation $\nabla \times \vec{H} = \vec{J}$ with necessary derivations for time varying field. [1+3+4]
8. Derive an expression for input intrinsic impendence using the concept of reflection of uniform plane waves. [6]

9. Find the amplitude of displacement current density inside a typical metallic conductor where $f = 1KHz$, $\sigma = 5\times10^7$ mho/m, $\varepsilon_r = 1$ and the conduction current density is $\vec{J} = 10^7 \sin(6283t - 444z)\hat{a}_y \ A/m^2$ [4]

10. Write all the Maxwell equations for the time varying field point form as well as integral form. [4]

11. A lossless transmission line with $Z_0 = 50\ \Omega$ with length 1.5 m connects a voltage $V_g = 60$ V source to a terminal load of $Z_L = (50+j50)\ \Omega$. If the operating frequency $f = 100$ MHz, generator impedence $Z_g = 50\ \Omega$ and speed of wave equal to the speed of the light. Find the distance of the first voltage maximum from the load. What is the power delivered to the load? [4+4]

12. What are the techniques that can be taken to match the transmission line with mismatched load? Explain any one. [2]

13. Write short notes on: [2×3]

a) Modes in rectangular wave guide
b) Antenna and its types

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27 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2070 Ashad

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BEL	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetic *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt* ***All*** *questions.*
- ✓ *The figures in the margin indicate* ***Full Marks****.*
- ✓ Assume that the **Bold Faced** letter represents a vector and $\mathbf{a}_{subscript}$ represents a unit vector.
- ✓ ***Necessary figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. At point P(-3,-4,5), express that vector that extends from P to Q(2,0,-1) in spherical coordinates. [5]

2. A point charge of 6μC (micro coulomb) is located at the origin, a uniform line charge density of 180nC/m lies along the x axis, and a uniform sheet of charge equal to $25nC/m^2$ lies in the z = 0 plane. Find **D** at B (1,2,4). [7]

3. Derive the equation for Energy Density in the electrostatic field. [7]

4. Derive the Laplacian Equation. Assuming that the potential V in the cylindrical coordinate system is the function of 'ρ' only, solve the Laplacian Equation by Integration Method and derive the expression for the Capacitance of the Cylindrical Capacitor using the same solution of V. [2+5]

5. A current of 0.3 ampere in the $\mathbf{a}_z$ direction in free space is in a filament parallel to the z-axis and passing through the point (1,-2,0). Find the Magnetic Field Intensity **H** at (0,1,0) if the filament lies in the interval $-4<z<4$. [6]

6. State and derive the Stoke's theorem. [1+4]

7. Calculate the value of the vector current density in cylindrical coordinates at P(ρ=1.5, ϕ=90°, z=0.5) if $\mathbf{H} = \frac{2}{\rho}(\cos 0.2\phi)\,\mathbf{a}_\rho$. [5]

8. An Electric field **E** in free space is given as $\mathbf{E} = 200\cos(10^8 t - \beta y)\,\mathbf{a}_z$ V/m. Find: [2+2+4]
   (a) Phase Constant (β);
   (b) Wavelength (λ);
   (c) Magnetic Field Intensity **H** at P (-0.1, 1.5, -0.4) at t = 4 nS.

9. Explain the term skin depth and loss tangent. Using Poynting Vector deduce the time-average power density for a lossless dielectric. [2+2+4]

10. Select the value of K so that each of the following pairs of fields satisfies Maxwell's equations in a region where $\sigma = 0$ and $\rho_v = 0$: [6]
$\mathbf{D} = 5x\,\mathbf{a}_x - 2y\,\mathbf{a}_y + Kz\,\mathbf{a}_z$ $\mu C/m^2$;
$\mathbf{B} = 2\,\mathbf{a}_y$ mT,
if $\mu = 0.25$ H/m and $\varepsilon = 0.01$ F/m.

11. A lossless transmission line with $Z_0 = 50\ \Omega$ is 200 m long. It is terminated with a load, $Z_L = 30 + j60\ \Omega$, and operated at a frequency of 0.5 MHz. Let the velocity v = 0.6c on the line where c = velocity of light = 3×10^8 m/s. Find: [2+2+4]
(a) The reflection coefficient (Γ).
(b) The voltage standing wave ratio on the line (VSWR).
(c) The input impedance (Z_{in}).

12. Explain why is it not possible to use waveguides at lower frequency? Write short notes on different types of modes used in rectangular waveguides. [2+4]

13. Give the definition of an antenna and list the different types of antenna that you have studied during your electromagnetics course. [1+1]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary formulas are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. Given a point P(-3, 4, 5), express the vector that extends from P to Q(2, 0, -1) in (a) Rectangular coordinates (b) Cylindrical coordinates (c) Spherical coordinates. [5]
2. Verify the divergence theorem (evaluate both sides of the divergence theorem) for the function $\vec{A} = r^2\,\vec{a}_r + r\sin\theta\cos\phi\,\vec{a}_\theta$, over the surface of quarter of a hemisphere defined by: $0 < r < 3$, $0 < \phi < \pi/2$, $0 < \theta < \pi/2$. [6]
3. Given the potential field $V = 100xz/(x^2+4)$ volts in free space: [7]
   a) Find $\vec{D}$ at the surface, z=0
   b) Show that the z=0 surface is an equipotential surface
   c) Assume that the z=0 surface is a conductor and find the total charge on that portion of the conductor defined by $0 < x < 2$, $-3 < y < 0$
4. State the uniqueness theorem and prove this theorem using Poisson's equation. [2+6]
5. State Amperes circuital law with relevant examples. The magnetic field intensity is given in a certain region of space as $\vec{H} = \frac{x+2y}{z^2}\vec{a}_y + \frac{2}{z}\vec{a}_z$ A/m. Find the total current passing through the surface $z = 4$, $1 < x < 2$, $3 < y < 5$, in the a_z direction. [3+5]
6. Define scalar and vector magnetic potential. Derive the expression for the magnetic field intensity at a point due to an infinite filament carrying a dc current I, placed on the z-axis, using the concept of vector magnetic potential. [3+5]
7. Define displacement current. Assume that dry soil has conductivity equal to 10^{-4} S/m, $\varepsilon = 3\varepsilon_0$ and $\mu = \mu_0$. Determine the frequency at which the ratio of the magnitudes of the conduction current density and displacement current density is unity. [2+5]
8. Derive the expression for electric field for a uniform plane wave propagating in a free space. [7]
9. State Poynting's theorem. An EM wave travels in free space with the electric field component $\vec{E} = (10\vec{a}_y + 5\vec{a}_z)\cos(\omega t + 2y - 4z)$ [V/m]. Find (a) ω and λ (b) the magnetic field component (c) the time average power in the wave. [1+2+2+2]
10. A lossless transmission line with $Z_0 = 50\Omega$ is 30m long and operates at 2 MHz. The line is terminated with a load $Z_L = (60+j40)\ \Omega$. If velocity (v) = 3×10^8m/s on the line. Find (a) the reflection coefficient, (b) the standing wave ratio and the input impedance. [2+2+3]
11. Explain the modes supported by Rectangular waveguide. Define cutoff frequency and dominant mode for rectangular waveguide. [2+2+2]
12. Write short notes on: [2+2]
    a) Antenna types and properties
    b) Quarter wave transformer

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27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Ashad

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX 503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary formulas are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. Given a vector field $\vec{D} = \frac{x\vec{a}_x + y\vec{a}_y}{x^2+y^2}$, evaluate D at the point where ρ=2, Φ=0.2π, and Z=5 in both cylindrical and Cartesian components. [5]
2. Define Gauss's law. A co-axial cable has inner conductors of radius r_1, outer conductor of radius r_2. Surface charge density on the surface of inner conductors is ρ_s.Use Gauss's law to derive an expression for electric field intensity in the region $r_1 \le r \le r_2$. [2+5]
3. Define potential field. Assuming that the potential V in the spherical coordinate system is function of r only, solve the laplacian equation and derive the expression for the capacitance of a spherical capacitor using the same solution of V.. [1+6]
4. Use boundary condition to find $\vec{E}_2$ in the medium 2 with boundary located at plane Z=0. Medium 1 is perfect dielectric characterized by ε_{r1}=2.5, medium 2 is perfect dielectric characterized by ε_{r2}=5, electric field in medium 1 is $\vec{E}_1 = \hat{a}_x + 3\hat{a}_y + 3\hat{a}_z$ v/m. [7]
5. Given the magnetic vector potential $\vec{A} = -\frac{\rho^2}{4}\vec{a}_z$ Wb/m, Calculate the total magnetic flux crossing the surface Φ=π/2, $1 \le \rho \le 2$m, $0 \le Z \le 5$m. [6]
6. Find the boundary condition for H and B at the interface between two isotropic homogeneous linear materials with permeabilities μ_1 and μ_2. [6]
7. For magnetic vector potential given in cylindrical co-ordinate system as $\overline{A} = 5r^3\,\hat{a}_z$ Wb/m in free space, find the magnetic field intensity, $\overline{H}$. [4]
8. Derive the equations to show that the electric field and the magnetic field component are in same phase for the wave propagation in perfect dielectric medium. [8]
9. Derive expressions for reflection co-efficient and transmission co-efficient for the case of normal incidence at boundary between two dielectric media where medium 1 is characterized by permittivity ε_1, permeability μ_1 and medium 2 is characterized by permittivity ε_2, permeability μ_2. Also explain why the concept of reflection is necessary. [5+3]
10. Write down the Maxwell's equations in point and phasor form for time varying fields. Define the pointing vector. [4+2]
11. A load impedance of (40+j70)Ω terminates a 100Ω transmission line that is 0.3λ long. Find the reflection coefficient at the load and the voltage at the input of the line. [2+4]
12. Define transverse electric and transverse magnetic mode of wave propagation in wave guide. A rectangular wave guide has dimensions a = 4.5cm, b=2.5cm. The medium within wave guide has relative permittivity ε_r=1, relative permeability u_r=1, conductivity σ=0 and conducting walls of wave guide are perfect conductors. Determine the cut off frequency for the modes $TE_{(1,0)}$, and $TM_{(1,1)}$. [2+2+2+2]
13. Write short notes on antenna and its properties. [2]

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27 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2068 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics *(EX 503)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary formulas are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. Transform vector $\vec{A} = \rho \sin\phi \, \vec{a}_z$ at point (1, 45°, 2) in cylindrical co-ordinate system to a vector in spherical co-ordinate system. [5]

2. The region X<0 is composed of a uniform dielectric material for which $\varepsilon_{r1} = 3.2$, while the region X>0 is characterized by $\varepsilon_{r2} = 2$. The electric flux density at region X<0 is $\vec{D}_1 = -30\vec{a}_x + 50\vec{a}_y + 70\vec{a}_z$ nC/m^2 then find polarization ($\vec{P}$) and electric field intensity ($\vec{E}$) in both regions. [3+3]

3. Define an electric dipole. Derive expression for electric field because of electric dipole at a distance that is large compared to the separation between charges in the dipole. [2+6]

4. Define Relaxation Time Constant and derive an expression for the continuity equation. [3+4]

5. Derive the equations for magnetic field intensity for infinite long coaxial transmission line carrying direct current I and return current -I in positive and negative Z-direction respectively. [7]

6. A current carrying square loop with vertices A(0,–2,2), B(0,2,2), C(0,2,–2) D(0,–2,–2) is carrying a dc current of 20A in the direction along A-B-C-D-A. Find magnetic field intensity $\vec{H}$ at centre of the current carrying loop. [6]

7. Elaborate the significance of a curl of a vector field. [3]

8. Derive the expressions for the electric field $\vec{E}$ and magnetic field $\vec{H}$ for the wave propagation in free space. [8]

9. The phasor component of electric field intensity in free space is given by $\vec{E}_s = (100\angle 45°)e^{-j50z}\,\vec{a}_x$ v/m. Determine frequency of the wave, wave impedance, $\vec{H}_s$, and magnitude of $\vec{E}$ at z = 10mm, t = 20ps. [2+2+2+2]

10. Write short notes on: (a) Loss tangent (b) Skin depth and (c) Displacement current density. [2+2+2]

11. Explain impedance matching using both quarter wave transformer and single stub methods. [3+3]

12. Explain in brief the modes supported by rectangular waveguides. Consider a rectangular waveguide with $\varepsilon_r = 2$, $\mu = \mu_0$ with dimensions a = 1.07cm, b = 0.43cm. Find the cut off frequency for TM_{11} mode and the dominant mode. [4+2+2]

13. Define antenna and list different types of antenna. [2]

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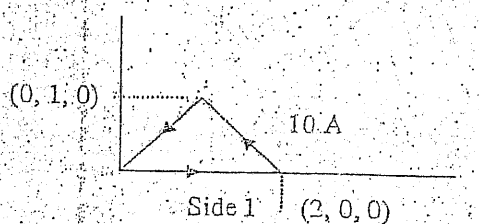
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics

- Candidates are required to give their answers in their own words as far as practicable.
- *Attempt All questions.*
- *The figures in the margin indicate Full Marks*
- *Necessary Smith Chart is attached herewith.*
- *Assume that the bold faced letter represents a vector and $a_{subscript}$ represents a unit vector.*
- *Assume suitable data if necessary.*

1. Express the vector field $W = (x-y)\, a_y$ in cylindrical and spherical co - ordinates. [5]
2. Find the equations for energy density in electrostatic field. [8]
3. A uniform sheet of charge $\rho_s = 40\varepsilon_0$ C/m^2 is located in the plane x = 0 in free space. A uniform line charge $\rho_L = 0.6$ nC/m lies along the line x = 9, y = 4 in free space. find the potential at point P (6, 8, −3) if V = 10V at A (2, 9, 3). [8]
4. What is physical significance of div **D**? Explain the importance of potential in the electro static field. [4]
5. What are the differences between curl and divergence? [4]
6. The condition triangle loop (shown in figure below) carries a current of 10A. Find **H** at (0, 0, 5) due to side 1 of the loop. [8]



7. State Maxwell's fourth equation. [2]
8. State and prove the Stokes theorem. [3]
9. For a non-magnetic materials having $\varepsilon_r = 2.25$ and $\sigma = 10^{-4}$ mho/m, find the numeric values at 5MHz for : [8]
   a) The loss tangent
   b) The attenuation constant
   c) The phase constant
   d) The intrinsic impedance
10. A load of 100 + j 150 Ohm is connected to a 75 ohm lossless line. Find using Smith Chart: [10]
    a) Reflection coefficient
    b) VSWR
    c) The load admittance
    d) Z_{in} at 0.4λ from the load
    e) Z_{in} at generator if line is 0.6λ long
11. Distinguish between conduction and displacement currents. [4]
12. Explain the term skin depth. Using pointing vector, deduce the time average power density for a dissipative medium. [7]
13. Write short notes on: [3×3]
    a) Antenna and its type
    b) TEM
    c) Waveguides

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15. State Barkhausen criteria and explain the principle of oscillation. [4]

16. Draw Wien Bridge Oscillator circuit and write the expression for frequency of Oscillation. [6]

17. Draw crystal oscillator circuit.

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27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Shrawan

Exam.	New Back (2066 Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electromagnetics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary datas are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. Transform vector field $\vec{A} = r\cos\phi\,\hat{a}_r + z\hat{a}_z$ at point P(1, 30°, 2) in cylindrical co-ordinate system to spherical co-ordinate system. [5]
2. Use Gauss's law to derive expression for electric field intensity in co-axial cable in the region $a < r < b$ where a is radius of inner conductor and b is radius of outer conductor. [5]
3. Derive the expression for energy density in electrostatic field. [6]
4. For a potential field $V = r^2z^2\sin\phi$ at point P(1,45°,1) in cylindrical co-ordinate system determine (a) Potential V (b) Electric field $\overline{E}$ (c) Electric flux density $\overline{D}$ (d) Volume charge density ρ_v and (e) unit vector in direction of $\overline{E}$. [5]
5. Differentiate between curl and divergence with required expression and physical meaning. [4]
6. State Stokes's theorem. Find magnetic field intensity at the origin if surface current $\overline{K} = 2\hat{a}_z$ A/m flows in the plane x = –2. [7]
7. If magnetic flux density, $\overline{B} = \frac{\mu_0}{4\pi}\int_l \frac{Id\overline{\ell}\times\overline{R}}{|\overline{R}|^3}$, then derive the expression for vector magnetic potential. [6]
8. Write about transformer emf and motional emf. [6]
9. What is polarization of wave vector? A time harmonic uniform plane wave $\overline{E}(x,y,z,t)$ with polarization in $\hat{a}_z$ direction, and frequency 150MHz is moving in free space in negative y direction and has maximum amplitude 2V/m. Determine (a) The angular frequency ω (b) Phase constant β (c) Expression for $\overline{E}(x,y,z,t)$, and (d) Expression $\overline{H}(x,y,z,t)$. [6]
10. What do you mean by pointing vector? Derive it's equation. [6]
11. If a transmission line having a characteristic impendence, $Z_0 = 200\Omega$, is operating at frequency 15MHz, with propagation constant $\gamma = j0.5m^{-1}$, then determine (a) Velocity of propagation (b) Wave length (c) Inductance (d) Capacitance. [4]
12. Define transverse electric mode and transverse magnetic mode. A rectangular wave guide has dimensions a = 3.5cm, b = 2cm and is to be operated below 15 GHz. The medium in the waveguide is air. Determine (a) Cut off frequency (b) Number of $TE_{m,n}$ and $TM_{m,n}$ modes that wave guide can support. [8]
13. Write short notes on: [3×4]
    a) Smith chart and it's application
    b) Antenna types and properties
    c) Skin effect, loss tangent, propagation constant
    d) Point form of Ampere's circuital law

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25 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Mangsir

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electromagnetics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary data are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. Transform $\overline{A}_c = x\hat{a}_x + xy\hat{a}_z$ at point (1,2,3) in Cartesian co-ordinate system to $\overline{A}_{cy}$ in cylindrical co ordinate system. [6]
2. Use Gauss's law to determine electric field intensity because of infinite line charge with uniform charge density ρ_l. [6]
3. Find potential at a point P(2,3,3) due to a 1nC charge located at Q(3,4,4), 1nC/m uniform line charge located at x = 2, y = 1 if potential at (3,4,5) is 0V. [6]
4. Use the boundary condition to find $\overline{E}_2$ in the medium 2 with boundary located at plane y = 0. Medium 1 is perfect dielectric characterized by $\varepsilon_{r1} = 3$, medium 2 is perfect dielectric characterized by $\varepsilon_{r2} = 5$, electric field in medium 1 is $\overline{E}_1 = 3\hat{a}_x + 2\hat{a}_y + \hat{a}_z$. [6]
5. Use two dimensional Laplace equation to determine potential distribution for the following boundary condition: V = 0 at x = 0, V = V_0 at x = a, V = 0 at y = 0 and V = 0 at y = b. [8]
6. State and explain Biot – Savart's law. [4]
7. For a given co – axial cable with inner conductor of radius 'a', outer conductor with inner radius 'b' and outer radius 'c' with current in the inner conductor 'I' and current in the outer conductor - 'I', determine $\nabla \times \overline{H}$ for $0 \le r \le a$, $a \le r \le b$, $b \le r \le c$. [10]
8. Consider a wave propagating in lossy dielectric with propagation consultant, $\gamma = \alpha + j\beta$. Derive expressions for α and β if medium is characterized by permittivity ε, permeability μ and conductivity σ. [8]
9. A uniform plane wave propagating in free space has $\overline{E} = 2\cos(10^7\pi t - \beta z)\hat{a}_x$, determine β and $\overline{H}$. [6]
10. A z-polarized uniform plane wave with frequency 100MHz propagates in air in the positive x-direction and impinges normally on a perfectly conducting plane at x = 0. Assuming the amplitude of the electric field vector to be 3mV/m, determine phasor and instantaneous expressions for [8]
    a) Incident electric and magnetic field vectors
    b) Reflected electric and magnetic field vectors
11. Derive the expression for input impedance of a transmission line with characteristic impedance, Z_0 excited by source, V with source impedance Z_s and terminated in load Z_l. [6]
12. Define transverse magnetic mode. A rectangular waveguide has dimensions, a = 5cm and b = 3cm. The medium within the waveguide has $\varepsilon_r = 1$, $\mu_r = 1$, $\sigma = 0$ and conducting walls of wave guide are perfect conductors. Determine the cutoff frequency for $TM_{1,1}$ mode. [6]

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