11 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Ashwin

Exam.	Back		
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**.*
- ✓ *The $\xrightarrow[a_{subscript}]{}$ denotes a unit vector along the direction of subscript.*
- ✓ ***Necessary formulas are attached herewith.***
- ✓ *Assume suitable data if necessary.*

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]

***

DIVERGENCE

Cartesian: $\nabla.\vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$

Cylindrical: $\nabla.\vec{D} = \frac{1}{\rho}\frac{\partial(\rho D_\rho)}{\partial \rho} + \frac{1}{\rho}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$

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

GRADIENT

Cartesian: $\nabla v = \frac{\partial v}{\partial x}\overrightarrow{a_x} + \frac{\partial v}{\partial y}\overrightarrow{a_y} + \frac{\partial V}{\partial z}\overrightarrow{a_z}$

Cylindrical: $\nabla v = \frac{\partial v}{\partial \rho}\overrightarrow{a_\rho} + \frac{1}{\rho}\frac{\partial v}{\partial \phi}\overrightarrow{a_\phi} + \frac{\partial v}{\partial z}\overrightarrow{a_z}$

Spherical: $\nabla v = \frac{\partial v}{\partial r}\overrightarrow{a_r} + \frac{1}{r}\frac{\partial v}{\partial \theta}\overrightarrow{a_\theta} + \frac{1}{r\sin\theta}\frac{\partial v}{\partial \phi}\overrightarrow{a_\phi}$

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

CURL

Cartesian: $\nabla \times \vec{H} = \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)\overrightarrow{a_x} + \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right)\overrightarrow{a_y} + \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right)\overrightarrow{a_z}$

Cylindrical: $\nabla \times \vec{H} = \left(\frac{1}{\rho}\frac{\partial H_z}{\partial \phi} - \frac{\partial H_\phi}{\partial z}\right)\overrightarrow{a_\rho} + \left(\frac{\partial H_\rho}{\partial z} - \frac{\partial H_z}{\partial \rho}\right)\overrightarrow{a_\phi} + \frac{1}{\rho}\left(\frac{\partial(\rho H_\phi)}{\partial \rho} - \frac{\partial H_\rho}{\partial \phi}\right)\overrightarrow{a_z}$

Spherical: $\nabla \times \vec{H} == \frac{1}{r\sin\theta}\left(\frac{\partial(H_\phi \sin\theta)}{\partial \theta} - \frac{\partial H_\theta}{\partial \phi}\right)\overrightarrow{a_r} + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial H_r}{\partial \phi} - \frac{\partial(rH_\phi)}{\partial r}\right)\overrightarrow{a_\theta} +$

$\frac{1}{r}\left(\frac{\partial(rH_\theta)}{\partial r} - \frac{\partial H_r}{\partial \theta}\right)\overrightarrow{a_\phi}$

***

22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Ashwin

Exam.	Back		
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.
- ✓ *Attemp t **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary formula is attached herewith.***
- ✓ *$\vec{A}$ represents a vector and $\vec{a}_{subscript}$ denotes a unit vector along the direction given by the subscript.*
- ✓ *Assume suitable data if necessary.*

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 -ρ_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_o. [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 ϵ_r = 2.25 an μ_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]

***

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

26 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 $a = 2.5\ \text{cm}$, $b = 1.2\ \text{cm}$. [2+4]

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

***

Cartesian: $\nabla . \overrightarrow{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$

Cylindrical: $\nabla . \overrightarrow{D} = \frac{1}{\rho}\frac{\partial(\rho D_\rho)}{\partial \rho} + \frac{1}{\rho}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$

Spherical: $\nabla . \overrightarrow{D} = \frac{1}{r^2}\frac{\partial(r^2 D_r)}{\partial r} + \frac{1}{r\sin\theta}\frac{\partial(\sin\theta D_\theta)}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial D_\phi}{\partial \phi}$

Gradient

Cartesian: $\nabla V = \frac{\partial V}{\partial x}\overrightarrow{a_x} + \frac{\partial V}{\partial y}\overrightarrow{a_y} + \frac{\partial V}{\partial z}\overrightarrow{a_z}$

Cylindrical: $\nabla V = \frac{\partial V}{\partial \rho}\overrightarrow{a_\rho} + \frac{1}{\rho}\frac{\partial V}{\partial \phi}\overrightarrow{a_\phi} + \frac{\partial V}{\partial z}\overrightarrow{a_z}$

Spherical: $\nabla V = \frac{\partial V}{\partial r}\overrightarrow{a_r} + \frac{1}{r}\frac{\partial V}{\partial \theta}\overrightarrow{a_\theta} + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\overrightarrow{a_\phi}$

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

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

Curl

Cartesian: $\nabla \times \overrightarrow{H} = \left(\frac{\partial H_z}{\partial x} - \frac{\partial H_y}{\partial z}\right)\overrightarrow{a_x} + \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right)\overrightarrow{a_y} + \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right)\overrightarrow{a_z}$

Cylindrical: $\nabla \times \overrightarrow{H} = \left(\frac{1}{\rho}\frac{\partial H_z}{\partial \phi} - \frac{\partial H_\phi}{\partial z}\right)\overrightarrow{a_\rho} + \left(\frac{\partial H_\rho}{\partial z} - \frac{\partial H_z}{\partial \rho}\right)\overrightarrow{a_\phi} + \frac{1}{\rho}\left(\frac{\partial(\rho H_\phi)}{\partial \rho} - \frac{\partial H_\rho}{\partial \phi}\right)\overrightarrow{a_z}$

Spherical: $\nabla \times \overrightarrow{H} == \frac{1}{r\sin\theta}\left(\frac{\partial(H_\phi\sin\theta)}{\partial \theta} - \frac{\partial H_\theta}{\partial \phi}\right)\overrightarrow{a_r} + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial H_r}{\partial \phi} - \frac{\partial(rH_\phi)}{\partial r}\right)\overrightarrow{a_\theta} +$

$\frac{1}{r}\left(\frac{\partial(rH_\theta)}{\partial r} - \frac{\partial H_r}{\partial \theta}\right)\overrightarrow{a_\phi}$

***

22 TRIBHUVAN UNIVERSITY

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 $\left(\vec{p}\right)$. 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]

***

DIVERGENCE

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

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

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

GRADIENT

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

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

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

CURL

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

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

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

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

LAPLACIAN

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

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

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

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 $\rho_L = 4\pi\ \text{Cm}^{-1}$ and in the x = 1 plane there is a surface charge with $\rho_s = 20\ \text{Cm}^{-2}$. 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]

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

   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 ρ = 2, π/4 < φ < π/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, σ = 5×10^7 mho/m, ε_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 Ω with length 1.5 m connects a voltage V_g = 60 V source to a terminal load of Z_L = (50+j50) Ω. If the operating frequency f = 100 MHz, generator impedence Z_g = 50 Ω 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

***

27 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

***

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 ε_{r1}= 3.2, while the region X>0 is characterized by ε_{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 ε_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]

***

१ 5

Divergence

Cartesian: $$\nabla.\overline{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

Cylindrical: $$\nabla.\overline{A} = \frac{1}{r}\frac{\partial}{\partial r}(rA_r) + \frac{1}{r}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

Spherical: $$\nabla.\overline{A} = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2 A_R) + \frac{1}{R\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta) + \frac{1}{R\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

Gradient

Cartesian: $$\nabla A = \frac{\partial A}{\partial x}\hat{a}_x + \frac{\partial A}{\partial y}\hat{a}_y + \frac{\partial A}{\partial z}\hat{a}_z$$

Cylindrical: $$\nabla A = \frac{\partial A}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial A}{\partial \phi}\hat{a}_\phi + \frac{\partial A}{\partial z}\hat{a}_z$$

Spherical: $$\nabla A = \frac{\partial A}{\partial R}\hat{a}_R + \frac{1}{R}\frac{\partial A}{\partial \theta}\hat{a}_\theta + \frac{1}{R\sin\theta}\frac{\partial A}{\partial \phi}\hat{a}_\phi$$

Curl

Cartesian: $$\nabla\times\overline{A} = (\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z})\hat{a}_x + (\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x})\hat{a}_y + (\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y})\hat{a}_z$$

Cylindrical: $$\nabla\times\overline{A} = (\frac{1}{r}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z})\hat{a}_r + (\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r})\hat{a}_\phi + \frac{1}{r}(\frac{\partial}{\partial r}(rA_\phi) - \frac{\partial A_r}{\partial \phi})\hat{a}_z$$

Spherical:

$$\nabla\times\overline{A} = \frac{1}{R\sin\theta}(\frac{\partial}{\partial \theta}(A_\phi \sin\theta) - \frac{\partial A_\theta}{\partial \phi})\hat{a}_R + \frac{1}{R}(\frac{1}{\sin\theta}\frac{\partial A_R}{\partial \phi} - \frac{\partial}{\partial R}(RA_\phi))\hat{a}_\theta + \frac{1}{R}(\frac{\partial}{\partial R}(RA_\theta) - \frac{\partial A_R}{\partial \theta})\hat{a}_\phi$$

Laplacian

Cartesian: $$\nabla^2 A = \frac{\partial^2 A}{\partial x^2} + \frac{\partial^2 A}{\partial y^2} + \frac{\partial^2 A}{\partial z^2}$$

Cylindrical: $$\nabla^2 A = \frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial A}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 A}{\partial \phi^2} + \frac{\partial^2 A}{\partial z^2}$$

Spherical: $$\nabla^2 A = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2\frac{\partial A}{\partial R}) + \frac{1}{R^2\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\frac{\partial A}{\partial \theta}) + \frac{1}{R^2\sin^2\theta}\frac{\partial^2 A}{\partial \phi^2}$$

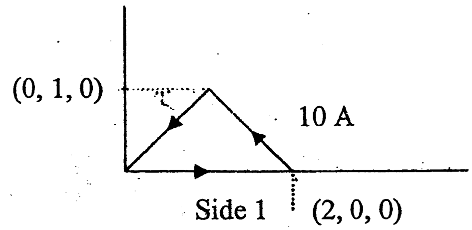
27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

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 $\mathbf{a}_{subscript}$ represents a unit vector.*
- ✓ *Assume suitable data if necessary.*

1. Express the vector field $\mathbf{W} = (x-y)\,\mathbf{a}_y$ 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]

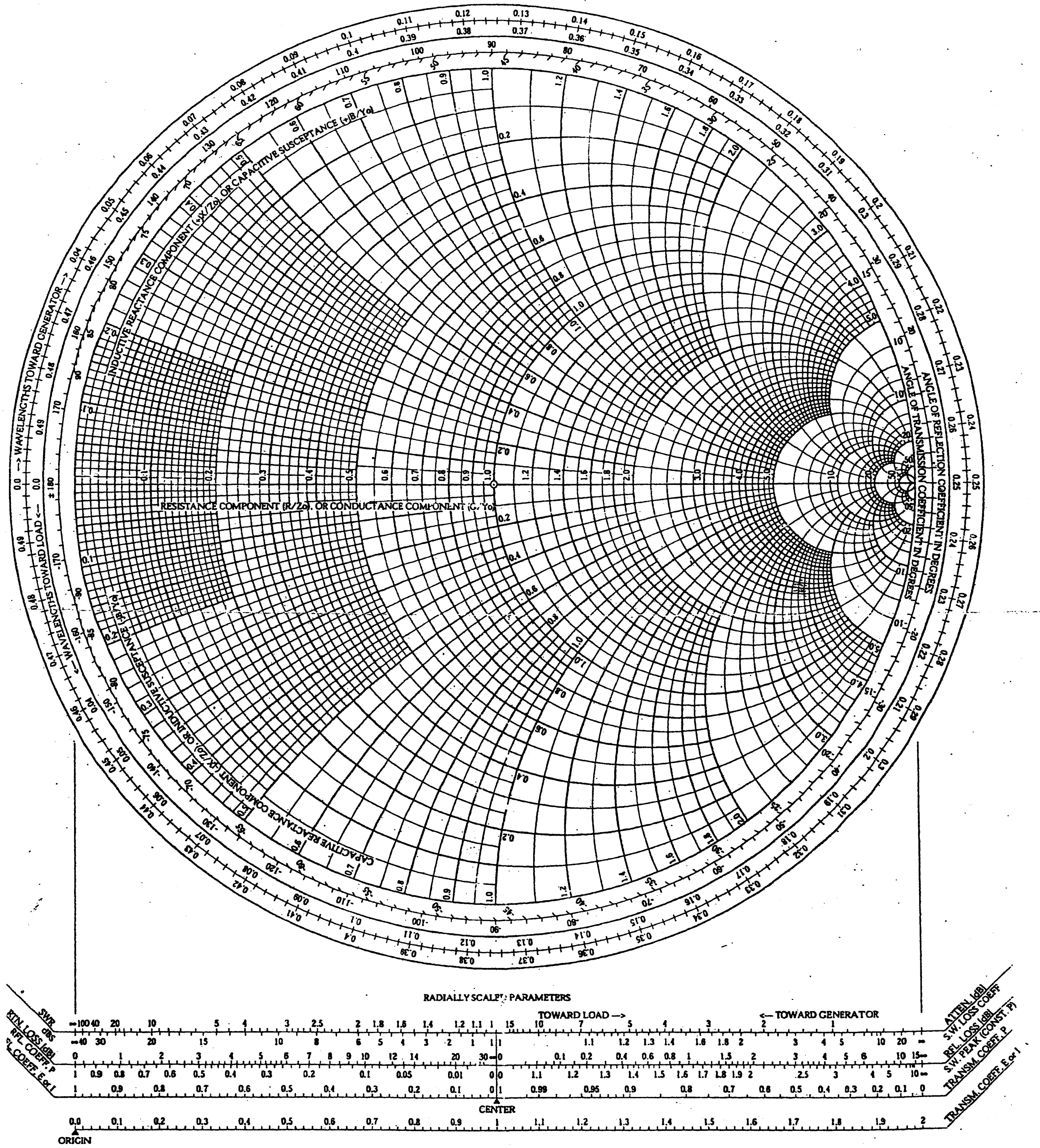


7. State Maxwell's fourth equation. [2]
8. State and prove the Stokes theorem. [3]
9. For a non-magnetic materials having $\varepsilon_r = 2.25$ and $\sigma = 10^{-4}$ mho/m, find the numeric values at 5MHz for : [8]
   a) The loss tangent
   b) The attenuation constant
   c) The phase constant
   d) 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

***

The Complete Smith Chart

Black Magic Design



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]

***

Divergence

Cartesian: $\nabla.\overline{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$

Cylindrical: $\nabla.\overline{A} = \frac{1}{r}\frac{\partial}{\partial r}(rA_r) + \frac{1}{r}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$

Spherical: $\nabla.\overline{A} = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2 A_R) + \frac{1}{R\sin\theta}\frac{\partial}{\partial\theta}(A_\theta \sin\theta) + \frac{1}{R\sin\theta}\frac{\partial A_\phi}{\partial\phi}$

Gradient

Cartesian: $\nabla A = \frac{\partial A}{\partial x}\hat{a}_x + \frac{\partial A}{\partial y}\hat{a}_y + \frac{\partial A}{\partial z}\hat{a}_z$

Cylindrical: $\nabla A = \frac{\partial A}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial A}{\partial \phi}\hat{a}_\phi + \frac{\partial A}{\partial z}\hat{a}_z$

Spherical: $\nabla A = \frac{\partial A}{\partial R}\hat{a}_R + \frac{1}{R}\frac{\partial A}{\partial \theta}\hat{a}_\theta + \frac{1}{R\sin\theta}\frac{\partial A}{\partial \phi}\hat{a}_\phi$

Curl

Cartesian: $\nabla\times\overline{A} = (\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z})\hat{a}_x + (\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x})\hat{a}_y + (\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y})\hat{a}_z$

Cylindrical: $\nabla\times\overline{A} = (\frac{1}{r}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z})\hat{a}_r + (\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r})\hat{a}_\phi + \frac{1}{r}(\frac{\partial}{\partial r}(rA_\phi) - \frac{\partial A_r}{\partial \phi})\hat{a}_z$

Spherical:

$$\nabla\times\overline{A} = \frac{1}{R\sin\theta}(\frac{\partial}{\partial\theta}(A_\phi\sin\theta) - \frac{\partial A_\theta}{\partial\phi})\hat{a}_R + \frac{1}{R}(\frac{1}{\sin\theta}\frac{\partial A_R}{\partial\phi} - \frac{\partial}{\partial R}(RA_\phi))\hat{a}_\theta + \frac{1}{R}(\frac{\partial}{\partial R}(RA_\theta) - \frac{\partial A_R}{\partial\theta})\hat{a}_\phi$$

Laplacian

Cartesian: $\nabla^2 A = \frac{\partial^2 A}{\partial x^2} + \frac{\partial^2 A}{\partial y^2} + \frac{\partial^2 A}{\partial z^2}$

Cylindrical: $\nabla^2 A = \frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial A}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 A}{\partial \varphi^2} + \frac{\partial^2 A}{\partial z^2}$

Spherical: $\nabla^2 A = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2\frac{\partial A}{\partial R}) + \frac{1}{R^2\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial A}{\partial\theta}) + \frac{1}{R^2\sin^2\theta}\frac{\partial^2 A}{\partial\phi^2}$

25 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Shrawan

Exam.		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 figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. a) Transform a point (x, y, z) in rectangular co-ordinates to a point (r, θ, ϕ) in spherical co-ordinate and vice-versa. [3]

   b) Transform the vector $\vec{B} = y\hat{a}_x - x\hat{a}_y + z\hat{a}_z$ into cylindrical co-ordinates. [4]

2. a) State Coulomb's law with an example. Derive an expression for electric field intensity $(\vec{E})$ at a point due to an infinite line charge having uniform charge density. [1+6]

   b) An infinitely long uniform line charge is located at y = 3, z = 5. If $\rho_L = 30$ nC/m, find $\vec{E}$ at (i) $P_A(0, 0, 0)$ (ii) $P_B(0, 6, 1)$ (iii) $P_C(5, 6, 1)$. [6]

3. a) State and explain Gauss's law. Define divergence and write down its physical significance as it applies to electric fields. [2+3]

   b) Consider a co-axial cable of length 50cm having inner radius of 1mm and an outer radius of 4mm with the spare between the conductors filled with air. Total charge on the inner conductor is 30 nC. Find (i) the charge density on the inner conductor and outer conductor (ii) $\vec{D}$ (iii) $\vec{E}$. [5]

4. a) Deduce how potential gradient can be used to determine the electric field intensity. What do you understand by electric dipole moment? [5+1]

   b) Given the potential field $V = 2x^2y - 5z$ and a point P(–4, 3, 6), find at P (i) V (ii) $\vec{E}$ (iii) $\hat{a}_E$ (iv) $\vec{D}$ (v) ρ_v. [5]

5. Explain how the conductivity of metals and semi-conductor changes with increase in temperature. Derive the point form of continuity equation. [3+3]

6. a) State Bio-Savart's law. Derive the equation for magnetic field intensity due to a co-axial cable carrying a uniformly distributed dc current I in the inner conductor and –I in the outer conductor. [2+6]

   b) Given $\vec{H} = (3r^2/\sin\theta)\hat{a}_\theta + 54r\cos\theta\hat{a}_\phi$ A/m in free space. Find the total current in the $\hat{a}_\theta$ direction through the conical surface $\theta = 20°$, $0 \le \phi \le 2\pi$, $0 \le r \le 5$. [6]

7. a) Explain how displacement current differs from conduction current. What do you understand by the term magnetization? What does the relative permeability of a substance indicate? [2+1+1]

b) A 9.4 GHz uniform plane wave is propagating in polyethylene ($\epsilon_r = 2.25$, $\mu_r = 1$). If the magnitude of the magnetic field intensity is 7 mA/m and the material is lossless, find (i) velocity of propagation (v_p) (ii) the wavelength (λ) (iii) the phase constant (β) (iv) the intrinsic impedance (η) (v) the magnitude of electric field intensity. [6]

8. a) What is a distortionless transmission line? Why are telephone lines required to be distortionless? [2+1]

b) A radar dish antenna is needed to be covered with a transparent plastic ($\epsilon_r = 2.25$, $\mu_r = 1$) to protect it from weather without any reflection of the signal back to the antenna. What should be the minimum thickness of the plastic cover if the operating frequency of antenna is 10 GHz? [6]

***