TRIBHUVAN UNIVERSITY INSTITUTE OF ENGINEERING **Examination Control Division** **2081 Bhadra**	**Exam.**	**Regular**		
	Level	BE	**Full Marks**	80
	Programme	BEL,BEX BEI,BCT	**Pass Marks**	32
	Year / Part	II / I	**Time**	3 hrs.

Subject: - Electro-magnetics *(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 formula sheet 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. Find $\vec{D}$ at P (6, 8, 10) caused by a point charge of 30 nC at the origin, a uniform line charge $\rho_L = 40\ \mu C/m$ on the z-axis and a uniform surface charge density $\rho_s = 57.2\ \mu C/m^2$ on the plane x = 9. [6]
3. Derive the expression for the Maxwell's equation in point form. [6]
4. Find the equation of a streamline that passes through the point P(1,4,-2) in the field $E = -8x/y\ \mathbf{a_x} + 4x^2/y^2\mathbf{a_y}$. [4]
5. Derive an expression for the magnetic field intensity produced by an infinitely long filament carrying current using Biot and Savart Law. [6]
6. What is curl? State and Prove Stokes theorem. [5]
7. A square loop of wire in the z = 0 plane with co-ordinates (1,0,0) (1,2,0) (3,2,0) and (3,0,0) carrying 2mA is placed in the field of an infinite filament on the y axis with current of 15A in $-a_y$ direction. Determine the total force on the loop. [6]
8. Derive an expression for standing Wave for both electric and magnetic field. Also indicate 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 dielectric and the region z > 0 may be of any material. [8]
9. A 1 MHz uniform plane wave with an amplitude of 25 V/m is propagating along $\hat{a}_x$ direction in a material for which $\varepsilon_r = 4$, $\mu_r = 9$ and $\sigma = 0$. Find: [8]
   a) The velocity of propagation.
   b) The phase constant.
   c) The intrinsic impedance.
   d) $\vec{E}(t)$ if $E_z = 0$ and $E_y = 25$ V/m at P (10, 10, 10) at 100 ns.
   e) $\vec{H}(t)$
10. Use boundary condition to find $\vec{E}_2$ 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 is $\vec{E}_1 = \vec{a}_x + 3\vec{a}_y + 3\vec{a}_z$ v/m. Also find the angles made by electric field $\vec{E}_2$ with the boundary interface. [6]
11. Find Capacitance per unit length of a co-axial cable using Laplace equation. [5]
12. Explain Faradays law. Derive the relation of the motional emf and displacement current. [5]
13. The parameters of a certain transmission line operating at 6×10^8 rad/s are L = 0.4 μH/m, C =40 pF/m, G = 80 mS/m, and R = 20 Ω /m. Find γ , α, β, λ, and Z0. [7]
14. Write short notes on types of antenna and antenna parameters. [3]

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Gradient:

- **Cartesian Coordinates:**
  $\nabla V = \frac{\partial V}{\partial x}\mathbf{a}_x + \frac{\partial V}{\partial y}\mathbf{a}_y + \frac{\partial V}{\partial z}\mathbf{a}_z$
- **Cylindrical Coordinates:**
  $\nabla V = \frac{\partial V}{\partial r}\mathbf{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\mathbf{a}_\theta + \frac{\partial V}{\partial z}\mathbf{a}_z$
- **Spherical Coordinates:**
  $\nabla V = \frac{\partial V}{\partial r}\mathbf{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\mathbf{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\mathbf{a}_\phi$

Divergence:

- **Cartesian Coordinates:**
  $\nabla \cdot \mathbf{F} = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$
- **Cylindrical Coordinates:**
  $\nabla \cdot \mathbf{F} = \frac{1}{r}\frac{\partial (rF_r)}{\partial r} + \frac{1}{r}\frac{\partial F_\theta}{\partial \theta} + \frac{\partial F_z}{\partial z}$
- **Spherical Coordinates:**
  $\nabla \cdot \mathbf{F} = \frac{1}{r^2}\frac{\partial (r^2 F_r)}{\partial r} + \frac{1}{r\sin\theta}\frac{\partial (F_\theta \sin\theta)}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial F_\phi}{\partial \phi}$

Curl:

- Cartesian Coordinates:
  $\nabla \times \mathbf{F} = \left(\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z}\right)\mathbf{a}_x + \left(\frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x}\right)\mathbf{a}_y + \left(\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y}\right)\mathbf{a}_z$
- Cylindrical Coordinates:
  $\nabla \times \mathbf{F} = \left(\frac{1}{r}\frac{\partial F_z}{\partial \theta} - \frac{\partial F_\theta}{\partial z}\right)\mathbf{a}_r + \left(\frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r}\right)\mathbf{a}_\theta + \left(\frac{1}{r}\frac{\partial (rF_\theta)}{\partial r} - \frac{1}{r}\frac{\partial F_r}{\partial \theta}\right)\mathbf{a}_z$
- Spherical Coordinates:
  $\nabla \times \mathbf{F} = \frac{1}{r\sin\theta}\left(\frac{\partial}{\partial \theta}(F_\phi \sin\theta) - \frac{\partial F_\theta}{\partial \phi}\right)\mathbf{a}_r + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial F_r}{\partial \phi} - \frac{\partial}{\partial r}(rF_\phi)\right)\mathbf{a}_\theta +$
  $\frac{1}{r}\left(\frac{\partial}{\partial r}(rF_\theta) - \frac{\partial F_r}{\partial \theta}\right)\mathbf{a}_\phi$

Laplacian:

- **Cartesian Coordinates:**
  $\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}$
- **Cylindrical Coordinates:**
  $\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 V}{\partial \theta^2} + \frac{\partial^2 V}{\partial z^2}$
- **Spherical Coordinates:**
  $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial \phi^2}$

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Year / Part	II / I	Time	3 hrs.

Subject: - Electro-magnetics *(EX 503)*

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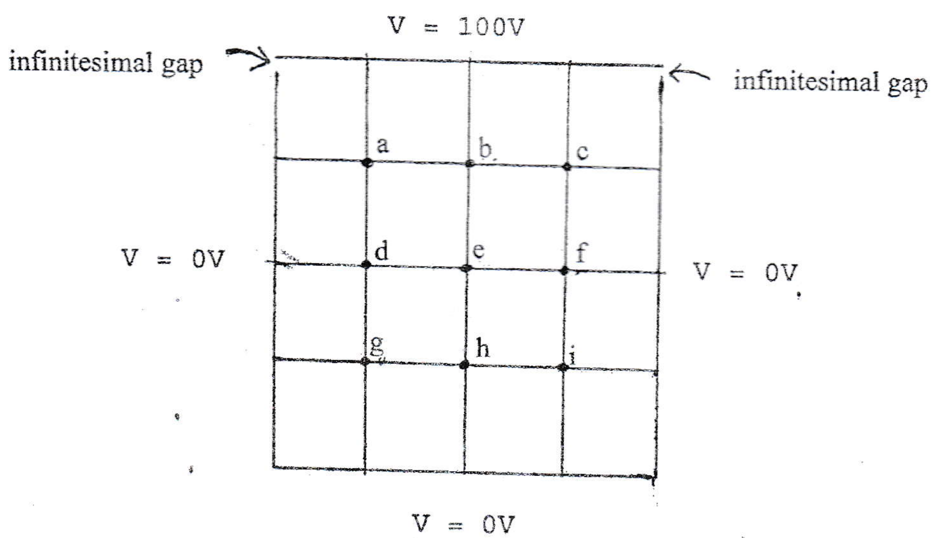
1. The Magnetic field Intensity in a certain region is given as $\vec{H} = 20\hat{a}_\rho - 10\hat{a}_\phi + 3\hat{a}_z A/m$. Transform this field vector into Cartesian co-ordinate at P(x=5, y=2, z=-1). [5]
2. A point charge of 6μc located at origin, uniform line charge density of 180nc/m lies along x-axis and uniform sheet charge of 25c/m^2 lies on z=0 plane. Find $\vec{D}$ at point (1,2,4). [6]
3. Differentiate between divergence and gradient. Let $V = \frac{\cos 2\phi}{\rho}$ in free space.(i) Find the volume charge density at point A (0.5,60°,1). (ii) Find the surface charge density on a conductor surface passing through the point B(2,30°,1). [2+3+3]
4. Define curvilinear square method for calculating capacitance. A square grid shown in figure below within a given potential. Find the potential at point a, b, c, d, e, f, g, h and i using iteration method. Complete it using single iteration only. [4+4]



5. Justify the maxwell's equation: $\oint_S \vec{B}.\vec{dS} = 0$ with necessary remarks. Derive an expression of magnetic field intensity for an infinite filament carrying a direct current using vector magnetic potential. [2+6]

6. Define Biot savart's law. Let the permittivity be 5μH/m in region A where x<0, and 20μH/m in region B where x>0. If there is a surface current density, $\vec{K} = 150\hat{a}_y - 200\hat{a}_z A/m$ at $x = 0$ and if $\vec{H} = 300\hat{a}_x - 400\hat{a}_y + 500\hat{a}_z A/m$, find $|\vec{H}_{tA}|$, $|\vec{H}_{NA}|$, $|\vec{H}_{tB}|$ and $|\vec{H}_{NB}|$ [2+6]

7. Define poynting vector. Using this deduce the time average power density for a dissipative medium. [2+6]

8. A conductor with cross-sectional area of $10 cm^2$ carries conduction current $\vec{J} = 0.2 \sin 10^9 t \hat{a}_z mA$. Given that $\sigma = 2.5 \times 10^6 S/m$, and $\epsilon_r = 6$. Calculate the magnitude of the displacement current density. [5]

9. A uniform plane wave in free space is given by Magnetic field intensity $\vec{H}$ in phasor form as: $\vec{H}_s = 400 \angle 30^\circ e^{-j250z} \hat{a}_y A/m$ Find:

   a) Angular frequency (ω).

   b) Wavelength (λ) and intrinsic impedance (η).

   c) Electric field intensity $\vec{E}(x, y, z, t)$ at z=50mm and t= 4pS. [2+2+4]

10. The parameters of a certain transmission line operating at 6×10^8 rad/s are L = 0.4μH/m, C = 40pF/m, G = 80mS/m, and R = 20Ω/m. Find γ, λ and Z_0 (characteristic impedance). [3+3+2]

11. A standard air-filled rectangular waveguide with dimensions 8.636cm×4.318cm is fed by a 4GHz carrier from a coaxial cable. Determine if a TE_{10} mode will be propagating or not. [6]

12. What are the parameters of antenna? List out the types of Antenna. [2]

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Subject: - Electromagnetics (*EX 503*)

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1. Express a scaler potential field $V=x^2+2y^2+3z^2$ in spherical coordinates. Find the value of P at a point (2,60°,90°). [4+1]
2. Derive the expression for an electric field intensity due to an infinite line charge using Gauss's Law. Find electric flux density at point P(6, 5, 4) due to a uniform line charge of 6nC/m at x = 4, y = 2, point charge 10nC at Q(3, 2, 4) and uniform surface charge density of 0.4nC/m^2 at x = 3. [3+5]
3. Two uniform charges 8 nC/m are located at x = 1, z = 2 and x = -1, y = 2 in free space respectively. If the potential at origin is 100 V. Find V at P (4, 1, 3). [6]
4. Derive Poisson Equation. Find the capacitance of parallel plate capacitor by solving Laplace equation with potential difference between the plates as V_0 [3+4]
5. Evaluate both sides of Stokes's theorem for the field $\vec{H} = 12\sin\theta\,\hat{a}_\phi$ and the surface $r = 4, 0 \le \theta \le 90°, 0 \le \phi \le 90°$. Let the surface have the $\hat{a}_r$ direction [6]
6. Differentiate Scalar Magnetic Potential and Vector Magnetic Potential. Given magnetic vector potential $\vec{A} = -\frac{\rho^2}{4}\hat{a}_z$ Wb/m. Calculate the total magnetic flux crossing the surface $\phi = \frac{\pi}{2}, 1 \le \rho \le 2, 0 \le z \le 5$. [2+6]
7. List out point form of Maxwell's equations in phasor form for time varying case. Using these equations, derive the electric field component of a uniform plane wave travelling in the perfect dielectric medium. [2+6]
8. A 9.375 GHz uniform plane wave is propagating in polythene (ε_r=2.26, μ_r=1). If the amplitude of the electric field intensity is 500 V/m and the material is assumed to be lossless: Find the phase constant, wavelength, velocity of propagation and intrinsic impedance. [2+2+2+2]
9. Explain the term Skin Depth. Using Poynting Vector deduce the time- average power density for a perfect dielectric. [4+4]
10. A lossless 60 Ω line is 1.8λ long and is terminated with pure resistance of 80 Ω. The load voltage is $15\angle30^0$ V.(i) Average power delivered to load (ii) Magnitude of minimum voltage on the line. [4+4]
11. What are the advantages of waveguides over transmission line? Consider a rectangular waveguide of dimension a=1.07 cm, b=0.43 cm. Find the cutoff frequency for TM_{11} mode. (E_r=2, $\mu=\mu_0$) [2+4]
12. Write short notes about antenna and its parameters. [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 $\nabla \cdot \vec{D} = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho D_\rho\right) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$

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

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

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

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

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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1. Transform the vector $\vec{A} = y\vec{a}_x - (x+y)\vec{a}_y + z\vec{a}_z$ at point P (-3,4,5) in cylindrical coordinate system. [5]

2. Define electric flux density. Given the field $\vec{D} = \frac{20}{\rho^2}(-\sin^2\phi\hat{a}_\rho + \sin 2\phi\hat{a}_\phi)$, evaluate both sides of the divergence theorem for the region bounded by $1 < \rho < 2$, $0 < \phi < 90°$, $0 < z < 1$. [1+7]

3. State Divergence's Theorem. A current density in certain region is given as $\vec{j} = \frac{400\sin\theta.\vec{ar}}{r^2} A/m^2$.

   Find the total current flowing through that portion of the spherical surface r = 0.8 bounded by $0.1\pi < \theta < 0.3\pi$, $0 < \phi < 2\pi$. [2+6]

4. Find the equation for Energy Density in the electrostatic field. [7]

5. Define curl. Evaluate both side of Stoke's Theorem for $\vec{H} = 8z\vec{a}_x - 4x^3\vec{a}_z A/m$ and rectangular path P(2,3,4) to Q(4,3,4) to R (2,3,1) to S(2,3,1) to P. [1+7]

6. State Biot-Savart's law. A filamentary current of 10A is directed in from infinity to the orgin on the positive x-axis and then block out to infinity along the positive z-axis. Use the Biot-Savart's law to determine $\vec{H}$ at P(0,1,0). [2+6]

7. State Faraday's law of electromagnetic induction. Explain motional induction and transformer induction with necessary expressions. [1+3+3]

8. Derive an expression for electric field and magnetic field for a uniform plane wave propagating in a free space. [7]

9. Determine skin depth, propagation constant and velocity of wave at 1 MHz in good conductor with conductivity of 1.9×10^7 mho per meter. [2+2+2]

10. A 200Ω transmission line is lossless, 0.25 λ long and is terminated in Z_L = 400Ω. The line has the generator with 80 < 0° V in series with 100Ω connected to the input. (a) Find the load voltage (b) Find the voltage at the midpoint of the line. [4+4]

11. Explain the different modes of propagation supported by waveguides. A rectangular waveguide has a cross-section of 2.5 cm × 1.2 cm. Determine if the signal of 5 GHz propagates in the dominant mode. [2+4]

12. What are the parameters of antenna? List out the types of Antenna. [2]

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Divergence

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

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

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

Gradient

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

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

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

Curl

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

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

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

Laplacian:

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

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

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

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- ✓ $\vec{A}$ represent a vector and $\vec{a}_{subscript}$ denotes a unit vector along the direction given by the subscript.
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1. Transform the vector $\vec{F}$ into the cylindrical co-ordinate system.
$\vec{F} = 10\vec{a_x} - 8\vec{a_y} + 6\vec{a_z}$ at point P(x = 10, y = -8, z = 6) [5]

2. Define electric dipole moment. 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 100 V, find V at P(4, 1, 3). [2+6]

3. State Gauss's Law. The region y < 0 contains a dielectric material for which $\varepsilon_{r1} = 2.5$, while the region y > 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 the electric field intensities, flux densities in region 2 and the angle θ_1, which is the angle made by normal component of $\vec{E}$ or $\vec{D}$ with total $\vec{E}$ or $\vec{D}$. [2+3+2+1]

4. Derive Poisson's 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 co-axial capacitor using the same solution of V. [2+5]

5. State Stoke's theorem. Evaluate both sides of Stroke's theorem for the field
$\vec{H} = 8xy\hat{a}_x - 5y^2\hat{a}_y A/m$ and the rectangular path around the region $2 \le x \le 5$, $-1 \le y \le 1$, z = 0. Let the positive direction of $\overrightarrow{dS}$ be $\hat{a}_z$. [1+7]

6. Define Ampere's Circuital law. Determine H at $P_2(0.4, 0.3, 0)$ in the field of an 8 A filamentary current directed inward from infinity to the origin on the positive x axis, and then outward to infinity along the y axis. [2+6]

7. Explain motional induction with necessary derivations. Correct the equation $\nabla \times \vec{H} = \vec{J}$ with necessary arguments and derivation for time varying fields. [3+4]

8. Derive the expression for electric and magnetic fields for a uniform plane wave propagating in a dissipative medium. [4+3]

9. 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, $\vec{E_S}$ at z = 25 mm and t = 4ps. [1+2+1+2]

10. Define the secondary parameters of a transmission line. A lossless transmission line with Zo = 50 ohm has a length of 0.4λ. The operating frequency is 300 MHz and it is terminated with a load $Z_L = 40 + j30$. Find: [2+1+2+3]
    a) Reflection Coefficient
    b) Standing wave ratio on the line (SWR)
    c) Input impedance (Zin)

11. Differentiate between TE and TM modes. Consider a rectangular waveguide with $\varepsilon_r = 4$, $\mu = \mu_0$ with dimensions a = 2.08 cm, b = 0.54 cm. Find the cutoff frequency for TM_{11} mode and the dominant mode. [3+3]

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

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Bhadra

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

Subject: - Electro-magnetics *(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 data are attached herewith.*
- ✓ $\vec{A}$ represent a vector and $\vec{a}_{subscript}$ denotes a unit vector along the direction given by the subscript.
- ✓ *Assume suitable data if necessary.*

1. Given a point P (-2, 6, 3) and vector field $\vec{A} = y\vec{a_x} + (xy + z)\vec{a_y}$, express P and $\vec{A}$ in spherical co-ordinate system. [5]
2. A point charge of 6μc located at origin, uniform line charge density of 180nc/m lies along x-axis and uniform sheet charge of 25 c/m^2 lies on z = 0 plane. Find $\vec{D}$ at point (1, 2, 4). [7]
3. Derive the expression for an electric field intensity due to an infinitely long line charge with charge density ρ_L by using Gauss's law. Find the volume charge density that is associated with the field $\vec{D} = xy^2\vec{a}_x + x^2y\vec{a}_y + z\vec{a}_z\ C/m^2$. [4+3]
4. State continuity equation. Given the vector current density $\vec{J} = 10\rho^2 z\vec{a}_\rho - 4\rho\sin^2\phi\vec{a}_\phi\ mA/m^2$. Determine the current following outward the circular band $\rho = 5,\ 0 < \phi < 2\pi, 2 < z < 2.8$. [2+4]
5. Differentiate between scalar magnetic potential and vector magnetic potential. If a vector magnetic potential is $\vec{A} = -(\rho^2/4)\vec{a}_z$wb/m, calculate total magnetic flux crossing the surface $\phi = \pi/2$, $1 \le \rho \le 2$ m and $0 \le z \le 5$ m. [4+4]
6. The region y < 0 (region 1) is air and y > 0 (region 2) has $\mu_r = 10$. 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 1, find $\vec{B}$ and $\vec{H}$ in region 2. [8]
7. Correct the equation $\nabla \times \vec{E} = 0$ for time varying field with necessary derivation. Also modify the equation $\nabla \times \vec{H} = \sigma\vec{E}$ with necessary arguments and derivation for time varying field. [3+4]
8. A uniform plane wave in free space is given by $\vec{H_S} = (250\angle 30°)e^{-j350z}\vec{a}_x\ V/m$. Determine phase constant, frequency of the wave, intrinsic impedance, $\vec{E_S}$ and the magnitude $\vec{H}$ of at z = 25 mm and t = 4ps. [1+1+2+2+2]
9. Derive the expression for electric and magnetic fields for a uniform plane wave propagating in a free space. [8]
10. A lossless transmission line is 80 cm long and operates at a frequency 1 GHz. The line parameters are L = 0.5 μH/m and C = 200 pF/m. Find the characteristics impedance, the phase constant, the velocity on the line, and the input impedance for $Z_L = 100\Omega$. [2+2+2+2]
11. Write short notes on TE and TM modes of rectangular waveguide. An air filled rectangular waveguide has cross-section of 2.3 cm × 1.02 cm. Calculate the cutoff frequency of the dominant mode (TE_{10}). [3+3]
12. Write short notes about antenna and its parameters. [2]

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

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

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

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

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

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

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INSTITUTE OF ENGINEERING

Examination Control Division

2078 Kartik

Exam.	Back		
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 data are attached herewith.***
- ✓ $\vec{A}$ represent a vector and $\vec{a}_{subscript}$ denotes a unit vector along the direction given by the subscript.
- ✓ *Assume suitable data if necessary.*

1. Transform a vector field $\vec{A} = 4\vec{a_x} - 2\vec{a_y} - 4\vec{a_z}$ into cylindrical coordinate system at a point P (2, 3, 5). [5]

2. A plane x = 2 carry a surface charge density 10 nC/m^2, a line x = 0 and z = 3 carry a line charge density 10 nC/m and a point charge of 10nC is at origin. Calculate $\vec{E}$ at (1, 1, -1) due to these charge configurations. [7]

3. Evaluate the both sides of divergence theorem for the field $\vec{D} = 2xy\vec{a}_x + x^2\vec{a}_y C/m^2$ and the rectangular parallelopiped formed by the planes x = 0 and 1, y = 0 and 2, and z = 0 and 3. [7]

4. If potential field in free space is $V = \frac{10}{r^2}\sin\theta\cos\phi$ V and point P is located at (2, 90°, 0°). Find: (a) $\vec{E}$ (b) direction of $\vec{E}$ at P (c) energy density at P. [2+2+2]

5. Find the vector magnetic field intensity $\vec{H}$ in Cartesian coordinates at P (2, 1, 3) caused filament of 12 Ampere(A) in a $\vec{a_z}$ direction on the z-axis and extending from z = 0 to z = 4. [8]

6. Consider a boundary at z = 0 which carries current $\vec{K} = \left(\frac{1}{\mu_0}\right)\vec{a_y}$ mAm. Medium 1 (z < 0) is filled with material whose $\mu_r = 6$ and medium 2 (z > 0) is filled with material whose $\mu_r = 4$. If $\vec{B_2} = 5\vec{a_x} + 8\vec{a_z}$ mT, find $\vec{B_1}$. [8]

7. Define Poynting vector. Using this deduce the time average power density for a dissipative medium. [2+5]

8. A uniform plane wave has a magnetic field component $\vec{H} = 15\cos(2\times10^8 t + \beta x)\vec{a_y}$ A/m in a medium characterized by $\sigma = 0$, $\varepsilon = 4\varepsilon_0$, $\mu = \mu_0$. Find [5+1+2]
   a) direction of propagation, phase constant β, wavelength λ, velocity v_p, intrinsic impedance η
   b) Magnitude of $\vec{H}$
   c) $\vec{E}$

9. A uniform plane wave in air partially reflects from the surface of a material whose properties are unknown. Measurements of the electric field in the region in front of the interface yield a 1.5 m spacing between maxima, with the first maximum occurring 0.75 m from the interface. A standing wave ratio (SWR) of 5 is measured. Determine the intrinsic impedance of the unknown material. [8]

10. A 50 Ω lossless transmission line is 0.4 λ long. The line is terminated with a load $Z_L = 40 + j30\ \Omega$. If the operating frequency is 300 MHz, find [2+2+4]

a) reflection coefficient (Γ)
b) standing wave ratio (s) and
c) input impedance (Z_{in})

11. Explain why TEM wave doesn't exist in a rectangular waveguide? A rectangular waveguide has dimensions a = 1 cm, b = 2 cm. The medium within the waveguides has $\varepsilon_r = 1$, $\mu_r = 1$, $\sigma = 1$. Find whether or not the signal with the frequency of 500 MHz will be transmitted in the $TE_{1,0}$ mode. [2+4]

12. What are the parameters of antenna? List out the different types of antenna you have studied. [1+1]

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

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

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

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

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

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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/m^2 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 $\vec{B} = 3\hat{a}_z$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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DIVERGENCE

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

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

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

GRADIENT

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

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

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

CURL

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

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

$$+\frac{1}{\rho}\left[\frac{\partial(\rho H_\phi)}{\partial \rho} - \frac{\partial H_\rho}{\partial \phi}\right]\mathbf{a}_z$$

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

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

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
2076 Ashwin

Exam.	Back		
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 charts and codes are attached herewith.__*
- ✓ *Assume suitable data if necessary.*

1. Given points A ($\rho = 5$, $\varphi = 70^{\circ}$, $z = -3$) and B ($\rho = 2$, $\varphi = -30^{\circ}$, $z = 1$),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 $\mathbf{K} = 150a_y - 200a_z$ A/m at $x = 0$,and if $\mathbf{H}_A = 300a_x - 400a_y + 500a_z$ A/m, find: (a) $|H_{LA}|$; (b) $|H_{NA}|$; (c) $|H_{LB}|$; (d) $|H_{NB}|$. [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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DIVERGENCE

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

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

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

GRADIENT

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

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

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

CURL

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

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

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

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

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Chaitra

Exam.	Regular / Back		
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 figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*
- ✓ *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 $\varepsilon_{R1}=3.2$, while the region z>0 is characterized by $\varepsilon_{R2}=2$. 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 ($\omega t+\beta y$) $\mathbf{a}_z$ 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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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* $\overrightarrow{a_{subscript}}$ *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, $\vec{D} = \dfrac{5\sin(\theta)\cos(\phi)}{r} a_r C/m^2$, 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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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: $\nabla \times \vec{H} == \frac{1}{r\sin\theta}\left(\frac{\partial(H_\phi \sin\theta)}{\partial \theta} - \frac{\partial H_\theta}{\partial \phi}\right)\overrightarrow{a_r} + \frac{1}{r}\left(\frac{1}{\sin\theta}\frac{\partial H_r}{\partial \phi} - \frac{\partial(rH_\phi)}{\partial r}\right)\overrightarrow{a_\theta} +$

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

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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]

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

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

Gradient

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

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

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

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

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

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

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

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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]

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

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

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

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

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

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
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 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 $f = 1KHz$, $\sigma = 5\times10^7$ 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
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
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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ঀ 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: $$\nabla^2 A=\frac{1}{R^2}\frac{\partial}{\partial R}(R^2\frac{\partial A}{\partial R})+\frac{1}{R^2\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial A}{\partial\theta})+\frac{1}{R^2\sin^2\theta}\frac{\partial^2 A}{\partial\phi^2}$$

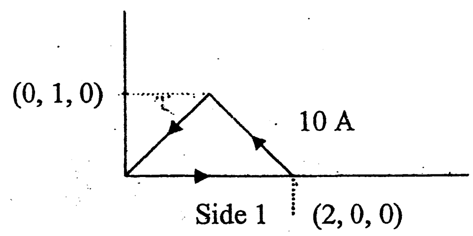
27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

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 $a_{subscript}$ 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

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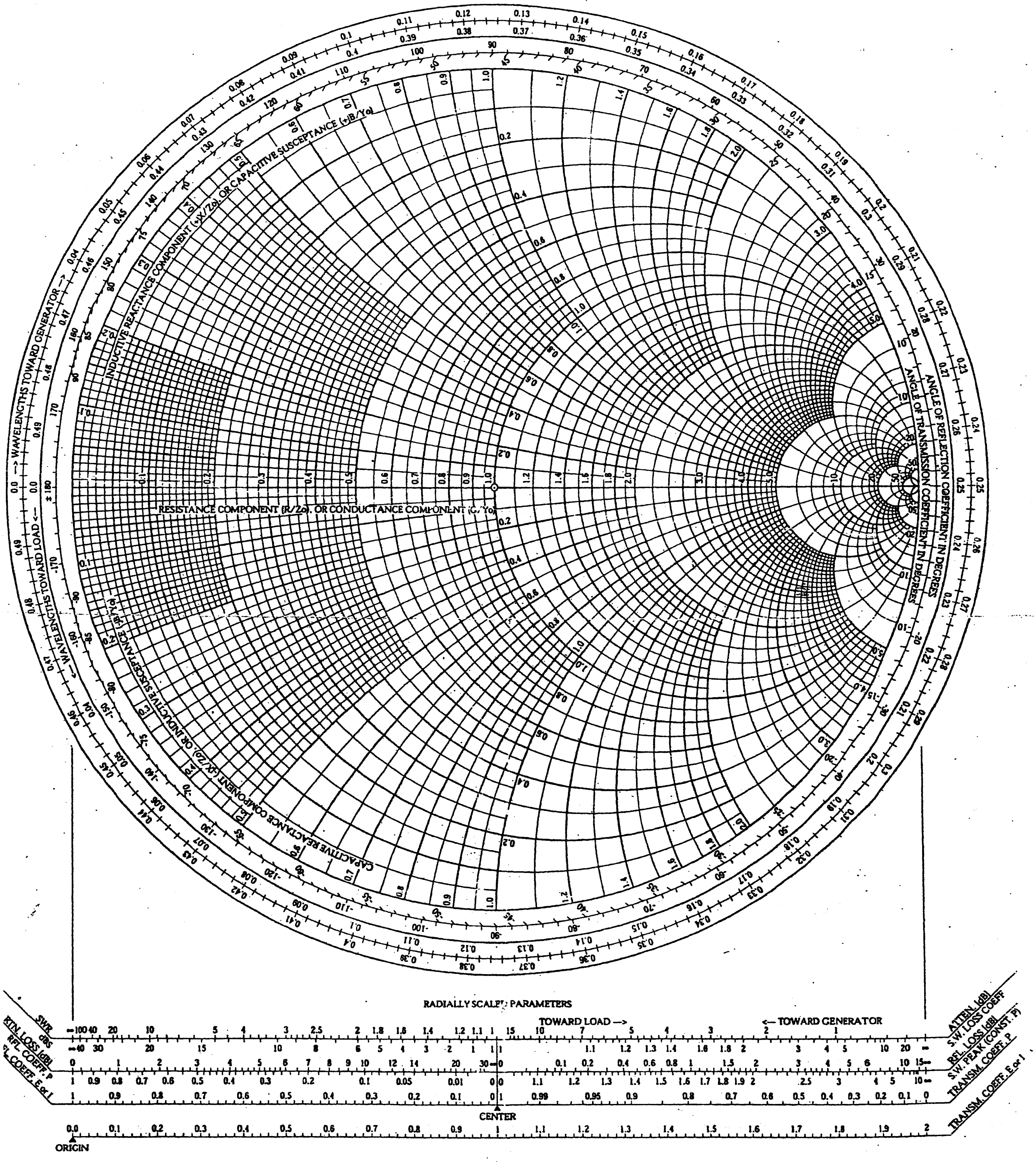
The Complete Smith Chart

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]

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

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

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

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: $$\nabla^2 A = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial A}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 A}{\partial \psi^2} + \frac{\partial^2 A}{\partial z^2}$$

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

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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 ρ_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]

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