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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June / July 2025 Semester End Main Examinations

Programme: B.E. **Semester: III**

Branch: Electrical and Electronics Engineering **Duration: 3 hrs.**

Course Code: 23EE3ESEFT/19ES3GCFTH/22EE3PCFTH **Max Marks: 100**

Course: Electromagnetic Field Theory/ Field Theory

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	CO	PO	Marks
1	a)	Derive an expression for electric field intensity at any point due to an infinite line charge.	CO1	PO1	**08**
	b)	For the point C (4.4, -115°,2) in cylindrical coordinate system, find the rectangular and spherical coordinates.	CO1	PO2	**04**
	c)	Given $\mathbf{D}=5\ r\ \sin^2\theta\ \cos^2\varphi\ \mathbf{a_r}$ C/m^2. Evaluate both sides of Gauss Divergence theorem for the region, r < 2.	CO2	PO2	**08**
		OR			
2	a)	State and explain Coulomb's law of force between two-point charges. Also, determine the vector force exerted on charge Q_A by Q_B, if Q_A= -20μC is located at A (-6, 4, 7) and Q_B=50μC is located at B (5, 8, -2).	CO2	PO2	**08**
	b)	Find the total charge contained in a 2 cm length of the electron beam for 2 cm < z < 4 cm, ρ = 1 cm and $\rho_v = -5e^{-10^5\rho z}\ \mu C/m^3$.	CO2	PO2	**06**
	c)	In a certain region of space $\mathbf{D}= 8xyz^4\ \mathbf{a_x}+ 4x^2z^4\ \mathbf{a_y} + 16x^2yz^3\ \mathbf{a_z}$ Find the total electric flux passing through the rectangular surface, z=2, 0 < x < 2, 1 < y < 3 in $\mathbf{a_z}$ direction.	CO2	PO2	**06**
		UNIT - II			
3	a)	Derive the expression of convection current density by considering the movement of a charge element.	CO2	PO2	**05**
	b)	If we take the zero reference for potential at infinity, find the potential at (0, 0, 2) in free-space, caused by (i) 12 nC/m on the line ρ= 2.5, z = 0 (ii) point charge of 18 nC at (1, 2, -1).	CO2	PO2	**08**
	c)	Evaluate the boundary conditions related to electric field at the interface of a conductor and free-space.	CO3	PO3	**07**
		OR			

	4	a)	Given $\mathbf{E} = y\,\mathbf{a_x} + x\,\mathbf{a_y} + 2\,\mathbf{a_z}$ V/m, determine the work done in carrying a 2C of charge from B (1,0,1) to A (0.8, 0.6, 1) along the shorter arc of the circle, $x^2 + y^2 = 1$, $z = 1$.	*CO2*	*PO3*	**07**
		b)	Obtain the expression for potential energy in a system of 'N' charges.	*CO1*	*PO2*	**07**
		c)	The current density is given in cylindrical co-ordinates as; $\mathbf{J} = -10^6\, z^{1.5}\, \mathbf{a_z}$ in the region $0 \le \rho \le 20\mu m$, and $\mathbf{J} = 0$, elsewhere. (i) Find the total current crossing the surface z = 0.1m in the $\mathbf{a_z}$ direction. (ii) If the velocity is 2×10^6 m/s at z = 0.1 m, find the ρ_v there.	*CO3*	*PO3*	**06**
			UNIT - III			
	5	a)	Derive the boundary conditions on **D** and **E** at the interface of the perfect dielectrics.	*CO2*	*PO2*	**07**
		b)	Given the potential field $V = [A\,\rho^4 + B\,\rho^{-4}] \sin 4\varphi$ volts, show that $\nabla^2 V = 0$. Also, determine the values of A and B, so that V= 100 volts and $\|\mathbf{E}\| = 500$ V/m at P (ρ=1, =22.5˚, z=2).	*CO2*	*PO2*	**07**
		c)	Derive the expression of capacitance of a coaxial capacitor having inner radius a, outer radius b and the length L.	*CO3*	*PO3*	**06**
			OR			
	6	a)	Calculate numerical values for V and ρ_v at point P in free-space, if $V = 5\rho^2 \cos(2\varphi)$, at P ($\rho = 3$, $\varphi = \frac{\pi}{3}$, $z = 2$).	*CO2*	*PO2*	**06**
		b)	Solve the Laplace's equation for the potential field in the homogeneous region between the two concentric conducting spheres with radii a and b (b > a), if potential V = 0 at r = b and $V = V_0$ at r = a. And find the capacitance between the two concentric spheres.	*CO3*	*PO2*	**08**
		c)	Let the region z < 0 be composed of a uniform dielectric material for which ε_r =3.2, while the region z > 0 is characterized by ε_r = 2. Let $\mathbf{D_1} = -30\,\mathbf{a_x} + 50\,\mathbf{a_y} + 70\,\mathbf{a_z}$ nC/m^2. Find (i) D_{N1} (ii) $\mathbf{D_{t1}}$ (iii) θ_1 (iv) $\mathbf{D_{N2}}$.	*CO3*	*PO3*	**06**
			UNIT - IV			
	7	a)	Given the points P_1 (1, 2, 3) and P_2 (-3, -1, 2), calculate $\Delta\mathbf{H_2}$, if incremental current element, $I_1\Delta\mathbf{L_1} = 2\pi(-\mathbf{a_x}+\mathbf{a_y}+2\mathbf{a_z})$ μA-m.	*CO2*	*PO2*	**05**
		b)	State and explain Ampere's circuital law. Using the same, derive the expression for magnetic field intensity at any point due to an infinite length filamentary current carrying conductor present on z-axis.	*CO3*	*PO3*	**07**
		c)	Evaluate the boundary conditions at the interface of two magnetic media.	*CO1*	*PO1*	**08**
			OR			

	8	a)	Consider a rectangular path $P_1(2, 3, 4)$ to $P_2(4, 3, 4)$ to $P_3(4, 3, 1)$ $P_4(2, 3, 1)$ to P_1. (i) Evaluate the closed line integral of **H** about this path, given that $\mathbf{H} = 3z\ \mathbf{a_x} - 2x^3\ \mathbf{a_z}$ A/m. (ii) Determine the quotient of the closed line integral and the area enclosed by the path as an approximation to $(\nabla \times \mathbf{H})_y$.	*CO3*	*PO3*	**06**
		b)	Two differential current elements, $I_1\Delta\mathbf{L_1}=3x10^{-6}\ \mathbf{a_y}$ A-m at $P_1(1,0,0)$ and $I_2\Delta\mathbf{L_2} =3x10^{-6}(-0.5\mathbf{a_x} + 0.4\ \mathbf{a_y} + 0.3\ \mathbf{a_z})$ A-m at $P_2(2,2,2)$ are located in free-space. Find the vector force exerted on $I_1\Delta\mathbf{L_1}$ by $I_2\Delta\mathbf{L_2}$.	*CO3*	*PO3*	**06**
		c)	Write an explanatory note on scalar and vector magnetic potentials.	*CO2*	*PO2*	**08**
			UNIT - V			
	9	a)	Starting from the equation of Faraday's law, obtain the point form of Maxwell's equation concerning spatial derivative of **E** and time derivative of **H**.	*CO3*	*PO3*	**05**
		b)	Derive the wave equations that characterize the propagation of uniform plane wave in free-space.	*CO2*	*PO2*	**07**
		c)	Starting from Maxwell's equation involving curl on **H**, obtain the equation of Poynting's theorem and interpret the same.	*CO2*	*PO2*	**08**
			OR			
	10	a)	Given $B_x = 2x10^{-4} \cos(10^5 t) \sin(10^{-3} y)$ T, $\varepsilon=10^{-11}$F/m and $\mu =10^{-5}$ H/m within a certain region; (i) Find **E** (ii) Find the total magnetic flux passing through the surface $x=0,\ 0 < y < 40m,\ 0 < z < 2m$ at $t=1\mu s$.	*CO3*	*PO3*	**07**
		b)	Explain the inadequacy of Ampere's circuital law for time-varying fields. Obtain a suitable correction for the same, which will remain consistent for both time and non-time-varying fields.	*CO2*	*PO2*	**06**
		c)	Given a non-magnetic material having $\varepsilon_r' = 3.2$ and $\sigma=1.5*10^{-4}$ S/m, find the following in free-space, (i) Loss tangent (ii) Attenuation constant (iii) Phase constant (iv) Intrinsic impedance. Consider f = 3MHz.	*CO3*	*PO3*	**07**

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