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BEC401

Fourth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025

Electromagnetic Theory

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	**a.**	State and explain Coulomb's law of force between two point charges in vector form.	**8**	**L1**	**CO1**
	b.	Define Electric field intensity. Derive the expression for the electric field intensity at a point due to infinite line charges (Uniformly charged wire).	**8**	**L2**	**CO1**
	c.	Two very small conducting spheres, each of mass 1 × 10-4 kg are suspended at common point by very thin filaments of length 0.2m. A charge Q Coulomb is placed on each sphere. The electric force of repulsion separates the spheres and an equilibrium is reached when the suspending filaments make an angle of 10º. Assuming e_r = 1 , g = 9.8N/kg and negligible mass for the filaments, find Q.	**4**	**L3**	**CO1**
		OR			
Q.2	**a.**	Define Point charge and using Coulomb's Law, derive expression for electric field intensity due to a point charge.	**8**	**L2**	**CO1**
	b.	Let a point Q1 = 25nc be located at A(4, -2, 7) and a charge Q2 = 60nc be at B(-3, 4, -2). Find $\vec{E}$ at C(1, 2, 3). Also find direction of the electric field. Given $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m.	**8**	**L3**	**CO1**
	c.	Two point charges of $+3 \times 10^{-9}$ C and -2×10^{-9} C are spaced two meter apart. Determine the electric field at a point which is one meter from each of the two point charges.	**4**	**L3**	**CO1**
		Module – 2			
Q.3	**a.**	State and prove Gauss Divergence theorem or divergence theorem.	**8**	**L2**	**CO2**
	b.	A point charge , Q = 30nc is located at the origin in Cartesian coordinates. Find the electric flux density and electric field intensity at (1, 3, -4)m.	**8**	**L3**	**CO2**
	c.	Derive an equation for equation of continuity (continuity of current).	**4**	**L3**	**CO2**
		OR			
Q.4	**a.**	State and prove Gauss law.	**8**	**L2**	**CO2**
	b.	Given that the potential field is $V = 2x^2y - 5z$. Find the potential , electric field intensity and volume charge density at point P(-4, 3, 6).	**8**	**L3**	**CO2**
	c.	State Gauss law in point form. Hence derive Maxwell's first equation.	**4**	**L3**	**CO2**

		Module – 3			
Q.5	**a.**	Starting from gauss law, derive Poisson's and Laplace equation. Hence define Laplace equation in all three coordinate systems.	**4**	**L2**	**CO3**
	b.	State and prove Stoke's theorem.	**8**	**L2**	**CO3**
	c.	Find the potential and volume charge density at P(0.5 , 1.5 , 1)m in free space. Given the potential field as under. i) $V = 2x^2 - y^2 - z^2$ volt ii) $V = 6\, r\, \phi\, z$ volt.	**8**	**L3**	**CO3**
		OR			
Q.6	**a.**	State and prove Biot – Savart's law.	**4**	**L1**	**CO3**
	b.	State and prove Ampere's circuital law.	**8**	**L1**	**CO3**
	c.	The magnetic field intensity is given in a certain region of space as : $\vec{H} = \left(\frac{x+2y}{z^2}\right)\hat{a}_y + \frac{2}{z}\hat{a}_z$ A/m. i) Find $\nabla \times \vec{H}$ ii) Find $\vec{J}$ iii) Use $\vec{J}$ to find total current passing through the surface , Z = 4 , $1 < x < 2$, $3 < y < 5$ in the $\hat{a}_z$ direction.	**8**	**L3**	**CO3**
		Module – 4			
Q.7	**a.**	Define current element. Derive an equation for force on a differential current element in a magnetic field.	**8**	**L2**	**CO4**
	b.	A point charge Q = 18nc has a velocity of 5×10^6 m/s in the direction $\vec{a} = 0.6\,\hat{a}_x + 0.75\,\hat{a}_y + 0.3\,\hat{a}_z$. Calculate the magnitude of the force exerted on the charge by the field $\vec{B} = -3\,\hat{a}_x + 4\,\hat{a}_y + 6\,\hat{a}_z$ mT.	**8**	**L3**	**CO4**
	c.	Calculate the force on a straight conductor of length 0.3m carrying a current 5A in the Z – direction where the magnetic field is $\vec{B} = 3.5 \times 10^{-3}\,(a\hat{x} - a\hat{y})$ Tesla. ($a\hat{x}$ and $a\hat{y}$ are unit vectors).	**4**	**L3**	**CO4**
		OR			
Q.8	**a.**	Derive magnetic boundary condition for i) Tangential component of magnetic field. ii) Normal component of magnetic field.	**8**	**L2**	**CO4**
	b.	A conductor 4m long lies along the Y – axis with a current of 10A in the $a\hat{y}$ direction. Find the force on the conductor if the field in the region is $\vec{B} = 0.05\, a\hat{x}$ tesla.	**8**	**L3**	**CO4**
	c.	Find the magnetic field intensity inside a magnetic material for following conditions : M = 100A/m and $\mu = 1.5 \times 10^{-5}$ H/m B = 200μT , X_m (Magnetic susceptibility = 15).	**4**	**L3**	**CO4**

		Module – 5			
Q.9	**a.**	Derive Integral and point form of Faraday's law.	**8**	**L2**	**CO5**
	b.	Given $\vec{E} = E_m \sin(wt - \beta z)\ \hat{ay}$ in free space. Calculate $\vec{D}$, $\vec{B}$ and $\vec{H}$.	**8**	**L3**	**CO5**
	c.	A copper disc 40cm diameter is rotated at 3000 r.p.m on a horizontal axis perpendicular to and through the centre of disc axis, lying in magnetic meridian. Two brushes make contact with the disc at diametrically opposite points on the edge. If horizontal component of earth's field is 0.02 mT, find the induced e.m.f between brushes.	**4**	**L3**	**CO5**
		OR			
Q.10	**a.**	State and derive Poynting's theorem for uniform plane waves.	**8**	**L2**	**CO5**
	b.	Derive general wave equation in electric and magnetic fields.	**8**	**L2**	**CO5**
	c.	For silver, the conductivity is $\sigma = 3.0 \times 10^6$ s/m. At what frequency will depth of penetration be 1mm?	**4**	**L3**	**CO5**

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