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Paper Code : PC-EE-303 / PC-EEE-303

PUID : 03521 (To be mentioned in the main answer script)

ELECTROMAGNETIC FIELD THEORY

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) The constant a for a solenoidal vector field

$F = 2x + 3yi + 3y - 2zj + (y + az) k$ is

a) 5 b) -5

c) 8 d) 3.

ii) The work done by the Lorentz force F on a charged particle is

a) $F.dr$ b) 0

c) $q / \varepsilon 0$ d) qF.

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iii) The 'dot' product of two vectors perpendicular to each other is

a) zero b) maximum

c) 1 d) -1.

iv) What causes electromagnetic wave polarization ?

a) Refraction

b) Reflection

c) Longitudinal nature of electromagnetic wave

d) Transverse nature of electromagnetic wave.

v) The electric field intensity at a point situated 4 metres from a point charge is 200 N/C. If the distance is reduced to 2 metres, the field intensity will be

a) 400 N/C b) 600 N/C

c) 800 N/C d) 1200 N/C.

vi) The electric dipole moment is directed from

a) $+q$ to $-q$

b) $-q$ to $+q$

c) perpendicular to the line joining $+q$ and $-q$

d) none of these.

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vii) The divergence of $G = xa_x + ya_y + za_z$ at point $P(2, 2, 2)$ is

a) 1 b) 2

c) 3 d) 4.

viii) For transmission line load matching over a wide range of frequencies, it is best to use a

a) balun

b) broadband directional coupler

c) double stub

d) single stub of adjustable position.

ix) Maxwell's equation is not completely symmetrical because

a) isolated magnetic charges do not exist

b) it is difficult to get curl of a vector in spherical co-ordinates

c) $\nabla \cdot \vec{D}$ is always zero

d) $\nabla \times \vec{H}$ does not exist in free space.

x) The force on a current element due to a magnetic field is zero if the angle between the current element and magnetic field is

a) zero b) $\frac{\pi}{4}$

c) $\frac{\pi}{2}$ d) $\frac{3\pi}{4}$.

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xi) Solid angle $d\omega$ subtended by a small surface element $\left(d.\vec{A}\right)$ θ when θ is kept constant at the origin is

a) $\sin\theta\, d\theta\, d\phi$ b) zero

c) $\sin\theta\, d\theta\, dr$ d) $d\phi\, d\theta\, dr$.

xii) The value of $\oint d\vec{l}$ along a circle of radius 2 units is

a) 0 b) 2π

c) 4π d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. State and proof Gauss's law in electrostatics.

3. In a loss-less transmission line, the velocity of propagation is $2{\cdot}5 \times 10^8$ m/s. If the capacitance of the line is 30 pF, find the inductance of the line, the characteristic impedance and phase constant at 100 MHz.

4. State and prove Helmholtz theorem.

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5. What values of A and B are required if the two fields $\vec{E} = 120\pi \cos\left(10^6 \pi t - \beta x\right) \hat{a}_y, V/m$ and $\vec{H} = A\cos\left(10^6 \pi t - \beta x\right) \hat{a}_z, A/m$ satisfy Maxwell's equations in linear isotropic homogeneous medium where $\varepsilon_r = \mu_r = 4$ and $\alpha = 0$?

6. A capacitor is charged to a certain potential by a battery through a resistance of 3 mega ohm. If it reaches $\frac{2}{3}$ of its final potential in 0·6 s, calculate its capacitance.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Show that for a transmission line $Z_0^{\,2} = \left(Z_i\right)_{SC}\left(Z_i\right)_{OC}$ where, Z_0 is the characteristic impedance of the line, $\left(Z_i\right)_{SC}$ and $\left(Z_i\right)_{OC}$ are the short-circuit and open-circuit impedance of the line respectively. 4

b) A 300 m long line has R = 4·5 KΩ, L = 0·15 mH, G = 60 m mho and C = 12 nF operated at f = 6 MHz. Find the characteristic impedance of the line, propagation constant and velocity of propagation. 3 + 3 + 2

c) For a distortion-less transmission line, show that the phase velocity is given by $v_p = 1/\sqrt{LC}$, where L and C are the inductance and capacitance per unit length of the line respectively. 3

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8. a) What is polarization of the electromagnetic wave ? 4

b) For a lossy dielectric material having $\mu_r = 1, \varepsilon_r = 48$, $\sigma = 20\ S/m$ calculate the attenuation constant, phase constant and intrinsic impedance at a frequency of 16 GHz. 3 + 3 + 3

c) What is Poynting vector ? 2

9. a) Using Biot-Savart's law prove that $\vec{\nabla} \cdot \vec{B} = 0$ 5

b) If at any position vector potential $\vec{A} = 5\left(x^2 + y^2 + z^2\right)\hat{i}$ evaluate the magnetic field at that position. 3

c) Compare the electrostatic field and magnetic field. 2

d) Show that for a finite current distribution $\vec{\nabla} \cdot \vec{B} = 0$. State the condition under which magnetic scalar potential exists. 4 + 1

10. a) A solenoid has length 2 m and mean diameter 0·05 m. It has four layers of 1000 turns each. Calculate the flux density at its centre when a current of 2·5 A flows through it. 6

b) Two straight wires each 10 cm long are parallel to one another and separated by a distance of 2 cms. They carry currents of 30 amps and 40 amps respectively. Calculate the force experienced by either of the wires. 6

c) What is Lorentz force in magnetostatics ? 3

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11. a) Evaluate $\iiint_V \vec{\nabla} \cdot \vec{A}\, dV$ where V is the volume of the cubical box bounded by the planes $x = 0$, $x = 1$; $y = 0$, $y = 1$; $z = 0$, $z = 1$. 5

b) Show that $\vec{\nabla} \cdot \vec{\nabla}\phi = \nabla^2\phi$. 5

c) If $\phi = x^2 - y^2 + 2z$, find $\vec{\nabla} \cdot \vec{\nabla}\phi$. 5

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