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Paper Code : EE-302

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) Given vectors, $\vec{A} = 2\vec{a}_x + a\vec{a}_y + 2\vec{a}_z$ and $B = a\vec{a}_x + \vec{a}_y + \vec{a}_z$. If $\vec{A}$ and $\vec{B}$ are normal to each other then a is

   a) 1 b) $-\frac{2}{3}$

   c) -1 d) 0.

   ii) The value of line integration along a circular path of radius 2 units is

   a) 0 b) 2π

   c) 8π d) 4π.

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iii) A vector with zero divergence is

a) irrotational b) a null vector

c) a scalar d) solenoidal.

iv) Ohm's law is obeyed by

a) Conduction current

b) Convection current

c) Conduction current & Convection current

d) None of these.

v) The closed loop integral of electric field is zero, if the electric field is caused by

a) a static charge

b) a time varying magnetic field

c) both (a) and (b)

d) none of these.

vi) The magnetic field strength $\vec{H}$ produced by an infinitely long conductor carrying current I at a distance r is given by

a) $\vec{H} = 2\pi rI$ b) $\vec{H} = I/2\pi r$

c) $\vec{H} = I/4\pi r$ d) $\vec{H} = 4\pi r/I$.

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vii) The magnetic flux $\vec{B}$ and vector potential $\vec{A}$ are related as

a) $\vec{B} = \vec{\nabla} \times \vec{A}$

b) $\vec{B} = \vec{\nabla} \cdot \vec{A}$

c) $\vec{A} = \vec{\nabla} \times \vec{B}$

d) $\vec{A} = \vec{\nabla} \cdot \vec{B}$.

viii) Which of the following is *not* Maxwell's equation ?

a) $\nabla \cdot \vec{D} = \rho$

b) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

c) $\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

d) $\nabla \cdot \vec{J} = -\frac{\partial \vec{\rho}}{\partial t}$.

ix) The mathematical form of Lorentz force is given by

a) $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$

b) $\vec{F} = q\vec{E} + q\vec{v} \cdot \vec{B}$

c) $\vec{F} = q\vec{E} + \vec{v} \cdot \vec{B}$

d) $\vec{F} = \vec{E} + \vec{v} \cdot \vec{B}$.

x) The direction of propagation of electromagnetic waves is given by the direction of

a) $\vec{E}$

b) $\vec{H}$

c) $\vec{E} \times \vec{H}$

d) $\vec{E} \cdot \vec{H}$

xi) Capacitance of the earth of radius R is

a) $2\pi\varepsilon_0 R$

b) $4\pi\varepsilon_0 R$

c) $\frac{4}{3}\pi\varepsilon_0 R^3$

d) $4\pi\varepsilon_0 \frac{1}{R}$.

xii) Curl of a gradient of a scalar function results in

a) non zero scalar

b) non-zero vector

c) zero vector

d) periodic function.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

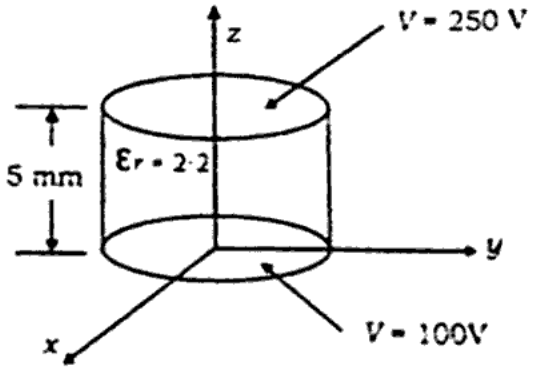
2. Explain the physical significance of the terms :
   (i) divergence of a vector field
   (ii) curl of a vector field.
3. Use Gauss's law to find the electric field at a point both
   (i) Inside
   (ii) Outside
   a uniformly charged sphere of radius a.
4. Establish force on current element $d\vec{F} = Id\vec{l} \times \vec{B}$ from the expression of Lorentz force on moving charge in a uniform steady magnetic field.
5. State Ampere's circuital law and write its expressions in both integral and differential forms.
6. From the fundamental principle, establish the relation, $\vec{\nabla} \times \vec{E} = -\partial\vec{B}/dt$.

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Determine the magnetic flux density $\vec{B}$ caused by a finite length of z at a distance d from the origin carrying current I.

   b) Apply Ampere's circuital law to the perimeter of a differential surface element and obtain the point form of Ampere's circuital law. 7 + 8
8. a) Derive the Maxwell's equations.
   b) Discuss Physical interpretation of Maxwell's equations. 10 + 5
9. a) An electric field in free space is given by $\vec{E} = 50\cos(10^8 t + \beta x)\,\vec{a}_y V/m$. Find out the direction of wave propagation and the phase constant of this wave. 2 + 2
   b) Find out the values of α (attenuation constant) and β (phase constant) in case of propagation of wave in a lossy dielectric. Also find out the expression of intrinsic impedance for this case. 7 + 4
10. a) Write down general procedure for solving Poisson's and Laplace's equation. 6
    b) Two parallel conducting disks shown in the figure are separated by 5 mm and contain a dielectric for which $\varepsilon_r = 2 \cdot 2$. Determine the charge densities on the disk. 9



11. a) State and prove Uniqueness theorem. 8

b) For two spherical shells with radii 0·15 m and 0·25 m respectively, the potentials are 150 V and 0 V respectively. Assuming free space between the shells, determine the electric field intensity in free space. Also evaluate maximum value of $\vec{E}$. 7

12. a) Develop the analogy between uniform plane EM waves and the electric transmission line.

b) A uniform transmission line has constants $R = 12\ m\Omega/m$, $G = 0{\cdot}8\ \mu\Omega^{-1}/m$, $L = 1{\cdot}3\ \mu H/m$ and $C = 0{\cdot}7\ nF/m$. At 5 kHz, find (i) impedance, (ii) dB attenuation in 2 km.

c) What do you mean by linearly polarized plane E.M. waves in free space ? 5 + 6 + 4

13. Write short notes on any *three* of the following : 3 × 5

a) Magnetic scalar and vector potentials

b) Continuity equation of current

c) Energy density in electrostatic field

d) Poynting vector.