

CS/B.Tech/(EE/EEE/ICE-New)/SEM-3/EE-302/2013-14

2013

## 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) If a vector field  $A = x\hat{a}_x + y\hat{a}_y + k\hat{a}_z$  represents a magnetic field, the value of  $k$  is

- a) 1                                      b) 2  
c) -1                                      d) -2.

ii) The capacitance of an isolated spherical conductor of diameter 1 cm is

- a) 0.556 pF                              b) 0.95  $\mu$ F  
c) 0.556  $\mu$ F                              d) 0.95 pF.

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iii) The work involved in moving a charge of 1 Coulomb from ( 6, 8, - 10 ) to ( 3, 4, - 5 ) along a straight line in the field  $E = -x\hat{a}_x + y\hat{a}_y - 3\hat{a}_z$  is

- a) 25.5 J                                      b) 15 J  
c) 20 J                                      d) None of these.

iv) A scalar potential  $\phi = xyz$ , then the vector  $F = \text{Grad } \phi$  is

- a) irrotational                              b) solenoidal  
c) both (a) & (b)                              d) none of these.

v) The direction of force on a conductor carrying current in positive  $y$ -axis and placed in magnetic field directed in positive  $x$ -axis will be

- a) negative  $x$ -axis                              b) negative  $y$ -axis  
c) positive  $z$ -axis                              d) negative  $z$ -axis.

vi) The magnetic field intensity ( in A/m ) at the centre of a circular coil of 1 m diameter and carrying a current of 2A is

- a) 8    b) 4  
c) 3    d) 2.

vii) The value of  $\nabla ( 1/r )$  is, where  $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$ 

- a)  $\vec{r}/r^2$                                       b)  $-\vec{r}/r^3$   
c)  $-\vec{r}/r^2$                                       d) none of these.

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viii) For the volume charge density  $\rho$ , the divergence of the electric field intensity will be

- a)  $\epsilon_0 \rho$                       b)  $\epsilon_0^2 \rho$   
 c)  $\frac{\rho}{\epsilon_0^2}$                       d)  $\frac{\rho}{\epsilon_0}$

ix) A transmission line is said to be distortionless if

- a)  $\frac{R}{G} = \frac{C}{L}$                       b)  $\frac{R}{G} = \frac{L}{C}$   
 c)  $RG = LC$                       d)  $R = 0$

x) Which of the following is zero ?

- a)  $\text{Grad Div } \vec{A}$                       b)  $\text{Div Grad } V$   
 c)  $\text{Div Curl } \vec{A}$                       d)  $\text{Curl Curl } \vec{A}$

xi) The intrinsic impedance of free space is given by

- a) 333 ohm                      b) 377 ohm  
 c)  $4\pi$  ohm                      d)  $2\pi$  ohm.

xii) For a lossless transmission line the characteristic impedance is given by

- a)  $\sqrt{C/L}$                       b)  $\sqrt{L/C}$   
 c)  $2\pi * \sqrt{C/L}$                       d)  $2\pi * \sqrt{L/C}$

xiii) Which of the following is a mathematically incorrect expression ?

- a) grad div                      b) curl grad  
 c) div grad                      d) curl curl.

### GROUP - B

( Short Answer Type Questions )

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

2. The vector potential  $\vec{A}$  and the scalar potential  $\phi$  in a certain region of space are given by

$$\vec{A} = \frac{1}{2} \alpha t (\vec{a}_y x - \vec{a}_x y)$$

$$\phi = \frac{1}{4} \alpha (x^2 + y^2)$$

where  $\alpha$  is a constant. Calculate the electric and magnetic fields.

3. State and explain Stokes' theorem.

4. a) What do you mean by skin effect ?

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b) If the skin depth is 80  $\mu\text{m}$  at 4 MHz in a certain conducting medium, calculate the skin depth if the frequency is changed to 16 MHz.

3

5. A transmission line has characteristic impedance of 70  $\Omega$  and a phase constant of 3 rad/m at 100 MHz. Calculate the inductance per meter and capacitance per meter of the line.

6. Use Gauss law to find the electric field at a point both (i) inside (ii) outside a uniformly charged sphere of radius  $a$ .

**GROUP – C****( Long Answer Type Questions )**Answer any *three* of the following.  $3 \times 15 = 45$ 

7. a) What is a Lorentz gauge ? 2
- b) Use this gauge to obtain the inhomogeneous wave equations for the scalar and vector potentials. 10
- c) Indicate how solutions of the above wave equations lead to retarded scalar and vector potentials. 3
8. a) Obtain Poynting theorem for conservation of energy in electromagnetic fields & discuss the physical meaning of each term in the resulting equation. 6 + 2
- b) An EM wave travels in free space with electric field component
- $$E = (10a_y + 5a_z) \cos(\omega t + 2y - 4z) \text{ V/m}$$
- Determine the following :
- i)  $\omega$  &  $\lambda$
- ii) the magnetic field component
- iii) the time average power in the wave. 2 + 2 + 3

9. a) State Biot-Savart's law. 2
- b) An infinitely long wire is carrying a current  $I$ . find the magnetic field intensity due to this current at a point, which is  $r$  m away from the wire. 4
- c) Find out the inductance of a long solenoid of radius  $r$  and  $N$  no. of turns. 4
- d) A square coil  $3 \text{ m} \times 3 \text{ m}$  is allowed to fall freely along a vertical keeping two opposite sides vertical, from the top of a tower  $80 \text{ m}$  high. If the magnetic field perpendicular to the plane of the coil is given by  $B(y) = [(5y/1000) + 0.0005] \text{ wb/m}^2$ .
- Find the induced *emf* in the coil just before hitting the ground. Here,  $y$  is the vertical position coordinate measured from the tower top. Accel. due to gravity is  $9.81 \text{ m/s}^2$ . 5
10. a) Derive the Maxwell's equation in electrostatic field. 6
- b) Why electrostatic field is called conservative field ? 4
- c) Derive Poisson's and Laplace's equation. 5

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11. Write short notes on any *three* of the following :  $3 \times 5$

- a) Magnetic material
  - b) Propagation constant
  - c) Modified Ampere's circuital law
  - d) Inductor energy and energy density.
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