# WEST BENGAL UNIVERSITY OF TECHNOLOGY

## EE(EI)-402

### FIELD THEORY

Time Allotted: 3 Hours | Full Marks: 70

*The questions are of equal value.*
*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. Answer any *ten* questions. $10 \times 1 = 10$

(i) If $r = x\,a_x + y\,a_y + z\,a_z$, the position vector of point (x, y, z) and $r = |r|$ which of the following is incorrect?

(A) grad r = r/r
(B) div r = 1
(C) Laplacian (r.r) = 6
(D) curl r = 0

(ii) Which of the following is zero?

(A) grad div
(B) curl grad
(C) div grad
(D) curl curl

(iii) Plane z = 10 m carries charge 20 $nC/m^2$. The electric field intensity at the origin is

(A) $-10\,a_z$ V/m
(B) $-18\pi\,a_z$ V/m
(C) $-72\pi\,a_z$ V/m
(D) $-360\pi\,a_z$ V/m

(iv) The work done by the force $F = 4\ a_x - 3\ a_y + 2\ a_z$ N in giving a 1 nC charge a displacement of $10\ a_x + 2\ a_y - 7\ a_z$ m is

(A) 103 nJ (B) 60 nJ (C) 64 nJ (D) 20 nJ

(v) The relaxation time of mica ($\sigma = 10^{-15}$ S/m, $\varepsilon_r = 6$) is

(A) $5 \times 10^{-10}$ s (B) $10^{-6}$ s (C) 15 hrs (D) 5 days

(vi) Ohm's law is obeyed by

(A) conduction current

(B) convection current

(C) conduction and convection current

(D) none of these

(vii) Direction of propagation of EM wave is obtained from

(A) E × H (B) E.H (C) E (D) H

(viii) Relation among magnetic vectors B,M and H is

(A) $B = \mu_0 H + M$ (B) $B = \mu_0 H + M$

(C) $H = \mu B + M$ (D) $H = B/\mu_0 - M$

(ix) Poynting vector has the unit

(A) $W\ m^{-2}$ (B) $Js^{-1}$ (C) W (D) $Jm^{-2}$

(x) Maxwell's equation $\nabla XH = J + \frac{\partial D}{\partial t}$ represents

(A) Magnetic vector potential

(B) Gauss's lax in magnetism

(C) Generalized Ampere's Circuital law

(D) Biot-Savart law

(xi) A transmission line is called distortionless line when

(A) R/L = G/C (B) R/G = C/L

(C) RG = L/C (D) R/G = LC

(xii) Unit of magnetic field intensity is

(A) A/m (B) $C/m^2$

(C) V/m (D) Tesla

## GROUP B
## (Short Answer Type Questions)

Answer any *three* questions. $3\times5 = 15$

2. The heat flow vector $H = k\ \nabla T$, where T is the temperature and k is the thermal conductivity. Show that when $T = 50\ \text{Sin}(\pi x/2)\ \text{Cosh}(\pi y/2)$, then div $H = 0$. 5

3. If $F = 2\rho z\ a_\rho + 3\ z\ \text{Sin}\varphi\ a_\varphi - 4\rho\ \text{Cos}\varphi\ a_z$, verify the Stoke's theorem for the open surface defined by $z = 1,\ 0 < \rho < 2,\ 0 < \varphi < 45°$ 5

4. A sphere of radius 10cm has $\rho_v = r^3/100\ C/m^3$. If D is to vanish for r>10 cm, calculate the value of a point charge that must be placed at the center of the sphere. 5

5. Prove that $\nabla XH = J + \partial D/\partial t$, the symbols have usual meaning 5

6. State how transformer emf differs from motional emf. Derive the necessary expressions. 5

## GROUP C
## (Long Answer Type Questions)

Answer any *three* questions. $3\times15 = 45$

7. (a) Derive the boundary conditions for a dielectric –dielectric boundary. 6
   (b) Two homogenous dielectric regions $1(\rho \le 4\ \text{cm})$ and $2(\rho \ge 4\ \text{cm})$ have dielectric constants 3.5 and 1.5, respectively. If $D_2 = 12a_\rho - 6a_\varphi + 9a_z\ nC/m^2$, calculate 3+3+3
   (i) $E_1$ and $D_1$
   (ii) $P_2$ and $\rho_{pv2}$
   (iii) the energy density for each region.

8. (a) Derive distribution of Electric flux density (D), Electric field (E) and Electric potential (V) for a uniformly charged sphere of radius a and charge density of $\rho_0$ C/m$^3$. 3+3+3

(b) A spherical charge distribution is given by 6

$$\rho_v = (\rho_0 r)/a, \quad r \leq a,$$
$$0, \quad r > a$$

Find V and E everywhere.

9. (a) Derive the Propagation constant and Characteristic impedance for a lossless transmission line from the transmission line equations. 5

(b) Derive an expression for the input impedance $Z_{in}$ of a lossless transmission line in terms of relevant parameters when the line is terminated in load impedance ($Z_L$). 5

(c) A transmission line with air as dielectirc has a characteristic impedance of 50Ω and a phase constant of 4 rad/m at 50 MHz. Calculate the inductance per meter and the capacitance per meter of the line. 5

10.(a) Obtain the Poynting theorem for the conservation of energy in an electromagnetic field and explain the significance of each term in the resulting equation. 6

(b) In a nonmagnetic medium $\mathbf{E}(x, t) = 3 \sin (2\pi \times 10^7 t - 0.6x)\mathbf{a_z}$ V/m 3+3+3

Find

(i) $\varepsilon_r$ and $\eta$

(ii) the time average power carried by the wave

(iii) the total power crossing a circular area of radius 5m in the plane x = 1.

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

(a) Boundary condition of magnetic field

(b) Faraday's Law

(c) Method of images

(d) Continuity equation ,

(e) Energy density in electrostatic field.