Reg. No.															

B.Tech. DEGREE EXAMINATION, NOVEMBER 2019

Third Semester

18EEC202T – ELECTROMAGNETIC THEORY

(For the candidates admitted during the academic year 2018-2019 onwards)

Note:

(i) **Part - A** should be answered in OMR sheet within first 45 minutes and OMR sheet should be handed over to hall invigilator at the end of 45th minute.

(ii) **Part - B** and **Part - C** should be answered in answer booklet.

Time: Three Hours Max. Marks: 100

PART – A (20 × 1 = 20 Marks)

Answer **ALL** Questions

1. Divergence of a vector $\vec{F}$ in a spherical coordinate system is given as

(A) $\frac{1}{r}\frac{\partial}{\partial r}(rF_x)+\frac{1}{r}\frac{\partial F_\phi}{\partial \phi}+\frac{\partial F_\theta}{\partial z}$ (B) $\frac{\partial F}{\partial r}\vec{a}_r+\frac{1}{r}\frac{\partial F}{\partial \phi}\vec{a}_\phi+\frac{\partial F}{\partial z}\vec{a}_z$

(C) $\frac{\partial F}{\partial \rho}\vec{a}_\rho+\frac{1}{\rho}\frac{\partial F}{\partial \theta}\vec{a}_\theta+\frac{1}{\rho\sin\theta}\frac{\partial F}{\partial \phi}\vec{a}_\phi$

(D) $\frac{1}{\rho^2}\frac{\partial}{\partial \rho}(\rho^2 F)+\frac{1}{\rho\sin\theta}\frac{\partial}{\partial \theta}(F\sin\theta)+\frac{1}{\rho\sin\theta}\frac{\partial F}{\partial \phi}$

2. Two vectors $\vec{A}$ *and* $\vec{B}$ are such that $\vec{A}+\vec{B}=n\vec{A}$, where 'n' is a positive scalar. The angle between $\vec{A}$ *and* $\vec{B}$ is _____

(A) $\frac{\pi}{2}$ (B) $\frac{3\pi}{4}$

(C) π (D) 2π

3. Which of the following is zero?

(A) grad.div (B) div grad

(C) curl curl (D) curl grad

4. Point charges $Q_1=1nC$ and $Q_2=2nC$ are at a distance apart. Which of the following statements are correct?

(A) The force on Q_1 is repulsive (B) The force on Q_2 is along the line joining them

(C) As the distance between them decreases, the force on Q_1 increases linearly (D) Both A and B

5. Plane $Z=10m$ carries charge $20nC/m^2$. The electric field intensity at the origin is _____

(A) $-10a_zV/m$ (B) $-18a_zV/m$

(C) $-72\pi a_zV/m$ (D) $-360\pi a_zV/m$

6. Match list I and list –II

List-I	List-II
A. $\nabla^2 V = \frac{-\rho_v}{\varepsilon}$	1. Gauss law
B. $\nabla^2 V = 0$	2. Divergence theorem
C. $\oint_s D.ds = Q$	3. Laplace equation
D. $\oint_V \nabla.Ddv = \oint_s B.ds$	4. Poisson's equation 5. Strokes theorem

(A) $A-4, B-2, C-5, D-1$ (B) $A-4, B-3, C-1, D-5$
(C) $A-3, B-1, C-2, D-4$ (D) $A-4, B-3, C-1, D-2$

7. An electric potential field is produced by point charges 1 μC and 4 μC located at $(-2,1,5)$ and $(1,3,-1)$ respectively. The energy stored in the field is _____
(A) 2.57 mJ (B) 5.27 mJ
(C) 5.14 mJ (D) 1.54 mJ

8. If $V_1 = X_1 Y_1$ is a product solution of Laplace equation, which of these is not a solution of Laplace's equation?
(A) $-10X, Y$ (B) $(X_1 - 2)(Y_1 + 3)$
(C) $X_1 Y_1 + 2xy$ (D) $X_1 Y_1 - x + y$

9. Which of these statement is not a characteristics of a static magnetic field?
(A) It is solenoidal (B) Magnetic flux lines are always closed
(C) It is conservative (D) It has no sinks or sources

10. Two concentric square loops A and B carry equal current in the same direction. The magnetic field at the centre due to the two loops A and B will be in the ratio
(A) 1:1.414 (B) 1.414:1
(C) 1:1 (D) 2:1

11. A multi-layer coil of 2000 turns of fine wire is 20 mm long and has a thickness 5 mm of winding. If the coil carries a current of 5 mA, the mmf generated is _____ ampere turn.
(A) 500 (B) 2000
(C) 4000 (D) 10

12. A very long solenoid with 2×2 cm cross section is made up of iron core $(\mu_r = 1000)$ with 4000 turns/m. If it carries a current of 500 mA, the energy per meter stored in the field is _____
(A) 8.042 J/m (B) 1.005 J/m
(C) 4.8042 J/m (D) 5.001 J/m

13. The ratio of conduction current density to the displacement current density is _____
(A) $\frac{j\sigma}{\omega\varepsilon}$ (B) $\frac{\sigma}{j\omega\varepsilon}$
(C) $\frac{\sigma\omega}{j\varepsilon}$ (D) $\frac{\sigma\varepsilon}{j\omega}$

14. For finite difference analysis, a rectangular plate measuring 10 by 20 cm is divided into 8 subregions by line 5 cm apart parallel to the edge of the plate. How many free nodes are there, if the edges are connected to some sources?
(A) 3 (B) 6
(C) 15 (D) 12

15. At the point $(1,2,0)$ in an electric field due to coplanar point charges, $E = 0.3\vec{a}_x - 0.4\vec{a}_y V/m$. A differential displacement of 0.05 m on an equipotential line at that point will lead to point
(A) $(1.04, 2.03, 0)$ (B) $(0.96, 1.97, 0)$
(C) $(1.04, 1.97, 0)$ (D) $(0.96, 2.03, 0)$

16. A loop is rotating about the y-axis in a magnetic field $\overline{B} = B_0 \sin \omega t \ \overline{a_x} Wb/m^2$. The voltage induced in the loop is due to
(A) Motional emf (B) Transformer emf
(C) Static field (D) A combination of motional and transformer emf

17. The depth of penetration of a mega-cycle wave into copper which has conductivity $\sigma = 5.8 \times 10^{-7} \mho/m$ and permeability approximately equal to that of free space is _____
(A) $6.602 \times 10^{-5} m$ (B) $8.602 \times 10^{-5} m$
(C) $2.602 \times 10^{-5} m$ (D) $4.602 \times 10^{-5} m$

18. Two dielectric medium, medium 1 is free space and medium-2 has $\varepsilon_2 = 4\varepsilon_0$ and $\mu = \mu_0$. The reflection coefficient for oblique incidence $\theta_1 = 30°$ with perpendicular polarization is_____
(A) 0.283 (B) –0.382
(C) 0.382 (D) –0.283

19. The intrinsic impedance of a good conducting medium is given by
(A) $\sqrt{\frac{\mu\omega}{\sigma}} \angle -45°$ (B) $\sqrt{\frac{\omega\sigma}{\mu}} \angle 45°$
(C) $\sqrt{\frac{\mu\omega}{\sigma}} \angle 45°$ (D) $\sqrt{\mu\sigma\omega} \angle 0°$

20. In a certain medium, $E = 10\cos\left(10^8 t - 3y\right)\vec{a}_x V/m$. What type of medium is it?
(A) Free space (B) Perfect dielectric
(C) Lossless dielectric (D) Perfect conductor

PART – B (5 × 4 = 20 Marks)
Answer **ANY FIVE** Questions

21. Given that $F = 1\hat{a}_x + y^2 z\hat{a}_y$. Verify Stroke's theorem for this vector field and the flat surface in the yz plane bounded by (0,0,0), (0,1,0), (0,1,1) and (0,0,1). Choose the contour in the clockwise direction.

22. A total charge of $10^{-8}C$ is distributed uniformly along a ring of radius 5 cm. Find the potential on the axis of the ring at a point 5m from the centre of the ring.

23. A solenoid of length 'l' and radius 'a' consists of 'N' turns of wire carrying current I. Show that at point 'P' along its axis

$$H = \frac{nI}{2}(\cos\theta_2 - \cos\theta_1)\vec{a}_z$$

Where $n = N/l$, θ_1 *and* θ_2 are the angles subtended at P by the end turn?

24. Find the value of 'K' so that the following pair of fields satisfies Maxwell's equations in region where $\sigma = 0$, $\rho_v = 0$

$E = 60\sin 10^6 t \sin 0.01Z\,\hat{a}_z V/m$ and

$\vec{H} = 0.6\cos 10^6 t \cos 0.01z\hat{a}_y A/m$ where $\mu = k$ and $\varepsilon = C_1$.

25. Summarize on the skin depth calculation for electromagnetic wave in a medium of good conductor.

26. Apply Gauss's law to derive the equation of a electric field intensity of an infinite plane sheet.

27. Prove the uniqueness theorem by contradiction.

PART – C (5 × 12 = 60 Marks)

Answer **ALL** Questions

28. a. A sphere of radius 'a' carries charge with a uniform volume density $\rho C/m^3$. Develop the equation of electric field intensity $\vec{E}$ at any distance r from the centre of the sphere.

(OR)

b.i. Discuss orthogonal coordinate systems and transformation of one coordinate to another.

ii. Three equal positive charges of 'q' each are located at three corners of a square of side 'l'. Find the electric field at the vacant corner of the square.

29. a. Develop the capacitance equation of a two wire transmission system using method of images.

(OR)

b. Using Laplace's equation, evaluate the potential distribution within a co-axial cable of length 'L' having an inner conductor of radius 'a' and an outer conductor of radius 'b', if potential of 'V_0' is applied at the inner conductor with reference to outer conductor. Also find electric field intensity.

30. a.i. An infinitely long wire of negligible cross-section is carrying current I. Develop the equation of magnetic field intensity due to this current carrying conductor at a point above the wire.

ii. Find the magnetic field intensity around a thin infinite current sheet which is located in Z =0, plane having a surface current density 'K' in y direction.

(OR)

b. Two magnetic materials are separated by a surface Z=0, having permeability $\mu_1 = 4\mu_0 H/m$ for region-1 where $Z > 0$ and $\mu_2 = 7\mu_0 H/m$ for region 2 where Z<0. There exists a surface current density $K_s = 60\vec{x}A/m$ at the boundary Z =0. For field $\vec{B}_1 = 1\vec{i} - 2\vec{j} + 3\vec{k}\,mT$ in region-1, evaluate the flux density in region2.

31. a. Develop the Maxwell's equation in point and integral form in time varying field.

(OR)

b.i. The electric field intensity associated with a plane wave travelling in a perfect dielectric medium having $\mu = \mu_0$ is given by $\vec{E} = 10\cos\left(6\pi \times 10^7 t - 0.4\pi z\right)\hat{i}\ V/m$. Find the phase velocity the permittivity of the medium and associated magnetic field vector $\vec{H}$. Velocity in free space = $3\times10^8 m/s$. (8 Marks)

ii. List out the significance of poynting theorem. (4 Marks)

32. a.i. Derive the Helmholtz equation in electric and magnetic field. (8 Marks)

ii. A uniform plane wave is specified by $\overline{H} = 2e^{-j0.1a}\hat{i}A/m$. If the velocity of the wave is $2\times10^8 m/s$ and the relative permeability is 1.6, find the frequency wave length and intrinsic impedance. (4 Marks)

(OR)

b.i. Deduce the wave propagation equation in a lossy dielectric. (9 Marks)

ii. Write a note on finite element analysis applied to electromagnetic field. (3 Marks)

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