Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

Make up examination

Winter Semester: 2022-23
Course Code: ECE 3004
Course Name: Electromagnetic Theory
Program & Sem: B. Tech (ECE)

Date: 28-01-2023
Time: 09:30 AM to 12:30 PM
Max Marks: 100
Weightage: 50%

Instructions:

(i) For numerical problems, all the works steps should be demonstrated
(ii) For missing data, make reasonable assumptions
(iii) All physical quantities may be assumed to be in SI units unless or otherwise specified

Part A [Memory Recall Questions]

Choose the correct option. (**10Qx 3M= 30M**) [Knowledge]

1. The angle θ between the vectors $\vec{P} = \hat{a}_x - \hat{a}_y + \hat{a}_z$ and $\vec{Q} = \hat{a}_x - 2\hat{a}_y + \hat{a}_z$ is

(a) 0° (b) 90° (c) 180° (d) 45°

2. The mathematical form of Ampere's circuital law with Maxwell's correction is

(a) $\nabla \times \vec{H} = \sigma\vec{E}$ (b) $\nabla \times \vec{H} = \sigma\vec{E} + \varepsilon\frac{\partial \vec{E}}{\partial t}$ (c) $\nabla \times \vec{H} = \varepsilon\frac{\partial \vec{E}}{\partial t}$ (d) $\oint \vec{B} \cdot \overrightarrow{dl} = \mu I$

3. Consider a vector function $\vec{A}$ and the following expressions

(i.) $\nabla \cdot (\vec{A} \cdot \vec{A})$ (ii) $\nabla \cdot (|\vec{A}| * \vec{A})$ (iii) $\nabla \times \nabla \times (\vec{A})$ (iv.) $\nabla \times (\nabla \cdot \vec{A})$

Which of the above expressions are invalid?

(a) i and ii (b) i and iv (c) ii and iii (d) iii and iv

4. Magnetic field can only be produced by

(a) Static electric charges (b) Static magnetic charges (c) Moving electric charges (d) Moving magnetic charges

5. The SI unit of electric field is ___ and its magnitude at a point located at infinity due to a point charge Q is ___

(a) (V/m), infinite (b) (C/m), zero (c) (C/m), infinite (d) (V/m), zero

6. What is proportional to the magnitude of the induced emf in the circuit?
(a) Rate of change of current in the circuit (b) Rate of change of resistance offered
(c) Rate of change of magnetic flux (d) Rate of change of voltage

7. If current in a conductor increases, then according to Lenz's law self-induced voltage will

(a) aid the increasing current (b) tend to decrease the amount of current (c) produce current opposite to the increasing current (d) aid the applied voltage

8. For an infinite line charge, the gaussian surface is a ___ whereas for a point charge it is ___

(a) cylinder, sphere (b) cylinder, cuboid (c) sphere, cylinder (d) sphere, cuboid

9. Current is a ___ quantity whereas current-density is a ___ quantity.

Scalar, scalar (b) vector, scalar (c) scalar, vector (d) vector, vector

10. The magnetic flux in a closed circuit varies with time t as $\phi = 4t^3 + 2t^2 - 15t + 3$. What is the magnitude of induced emf at t = 1s?
a) 3 V b) 4 V c) 5 V d) 6 V

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries ten marks. **(5Qx 10M= 50M)**

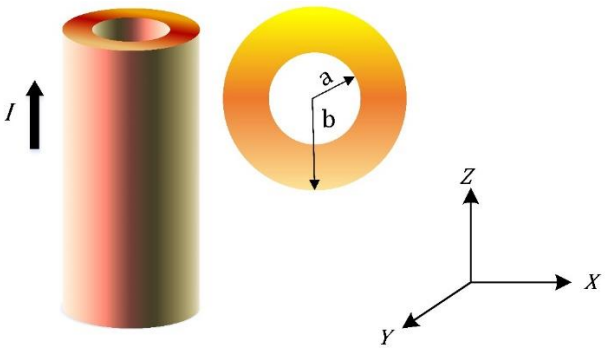
Q.NO.11. The potential function V is of the form $V = xy + yz + zx$. Does this potential satisfy the Laplace's equation? What is the expression for E-field due this potential at $P\ (1,1,1)$?

[**10**] (C.O.No.2) Comprehension

Q.NO.12. A vector $\vec{r}$ is given as $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, $|\vec{r}\,| = r$ and $f(r)$ is a scalar function of r denoted as $f(r) = r^2$. Find the expression for (a) $\nabla \cdot \vec{r}$ (b) $\nabla \times \vec{r}$ (c) $|\vec{r}\,|$ (d) ∇r and (e) $\nabla f(r)$ in terms of x, y and z only.
[**10**] (C.O.No.1) Comprehension

Q.NO.13. What is the statement of Coloumb's law? Write down the mathematical form of this law. Consider two point charges $1\ mC$ and $-2\ mC$ are located at the points $A_1\ (-1,0)$ and $A_2\ (+1,0)$.
(a) Calculate the electric force on each charge due to the other
(a) Calculate the electric force on a third charge of $10\ nC$ charge at $A_3\ (\sqrt{2},0)$
[**10**] (C.O.No. 2) Comprehension

Q.NO.14. Q9. Consider a hollow cylinder of inner radius *a* and an outer radius *b* as shown in the figure below. The cylinder is placed along the Z-axis lengthwise and carries a current *I*. Using Ampere's circuital law, find the magnetic field intensity $\vec{H}$ in the following regions (i)$r < a\ (ii) a < r < b\ (iii)\ r > b$



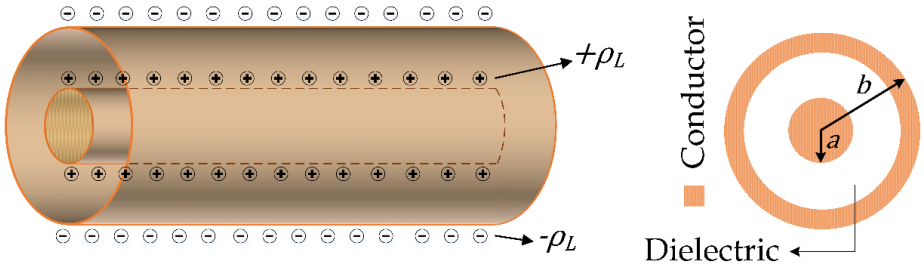
enclosed by the rectangular region bounded by $-1 \le x \le 1$ and $-2 \le y \le 2$ using Ampere's circuital law.
[**10**] (C.O.No. 2) Comprehension

Q.NO.15. Write down the four Maxwell's equations in both differential and integral forms. Then discuss the physical significance of each of these forms in details. [**10**] (C.O.No.3) Comprehension

Part C [Problem Solving Questions]

Answer all the Questions. Each question carries ten marks (2Qx10M=20M)

Q.NO.21 A coaxial cable is an important component in microwave engineering and is frequently used to carry high frequency signals for broadband internet, antennas, cable televisions, just to name a few. The figure below shows a coaxial cable comprising of an inner conductor (of radius *a*) surrounded by a dielectric and encased in a metallic jacket (of radius *b*). Assume the charge density on the inner and outer conductors to be $+\rho_L$ and $-\rho_L$ (Coloumb/metre) and the permittivity of the dielectric medium to be ε (Farad/metre). Using Gauss's law, arrive at expression for the electric field at various regions of the coaxial cable. [**10**] (C.O.No.2) Application



Q.NO.22 An electric field intensity is given in free-space as

$$\vec{E} = 100 * \cos\left(2\pi 10^6 t - x * 10^8 \sqrt{\mu_0 \varepsilon_0}\right)\hat{a}_y \ \left({}^{V}/_{m}\right).$$

Calculate the following

1. Amplitude of the electric field, frequency and speed of propagation of the wave
2. Directions of propagation of the wave and that of the magnetic field associated with this wave
3. Phase-constant β
4. If the free-space is replaced by a medium of $\varepsilon_r = 25$, calculate the velocity of propagation of the wave in this medium

[**10**] (C.O.No 4) Application