| Reg. No. | | | | | | | | | | | | | | | |
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| Question Paper Code | 13201 |
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**B.E. / B.Tech. - DEGREE EXAMINATIONS, NOV / DEC 2024**

Third Semester

**Electrical and Electronics Engineering**

**20EEPC303 - ELECTROMAGNETIC THEORY**

Regulations - 2020

Duration: 3 Hours | Max. Marks: 100

**PART - A (MCQ) (20 × 1 = 20 Marks)**

Answer ALL Questions

| | | Marks | K – Level | CO |
|---|---|---|---|---|
| 1. | The vector field is<br>(a) solenoidal (b) irrotational<br>(c) both solenoidal and irrotational (d) neither solenoidal nor irrotational | 1 | K1 | CO1 |
| 2. | Given the two vectors, $\vec{A} = 2\overrightarrow{a_x} - 5\overrightarrow{a_y} - 4\overrightarrow{a_z}$ and $\vec{B} = 3\overrightarrow{a_x} + 5\overrightarrow{a_y} + 2\overrightarrow{a_z}$ Find the dot product.<br>(a) -48 (b) -27 (c) -39 (d) -16 | 1 | K1 | CO1 |
| 3. | The Stoke's theorem uses which of the following operation?<br>(a) Divergence (b) Gradient (c) Curl (d) Laplacian | 1 | K1 | CO1 |
| 4. | What is the physical significance of the divergence of an electric field?<br>(a) It represents the net electric charge density within a volume<br>(b) It indicates the magnetic flux density leaving a volume<br>(c) It determines the potential at a point due to a charge<br>(d) It measures the resistance to electric flow in a material | 1 | K1 | CO1 |
| 5. | Which statement about the electric field in a conductor in electrostatic equilibrium is true?<br>(a) The electric field is zero everywhere inside the conductor<br>(b) The electric field is non-zero everywhere inside the conductor<br>(c) The electric field is maximum at the center of the conductor<br>(d) The electric field varies linearly inside the conductor | 1 | K1 | CO2 |
| 6. | What is the effect of a dielectric material when placed in an electric field?<br>(a) It increases the electric field strength<br>(b) It decreases the capacitance<br>(c) It decreases the electric field strength<br>(d) It has no effect on the electric field | 1 | K1 | CO2 |
| 7. | What does Poisson's equation solve for in electrostatics?<br>(a) Electric potential in the presence of free charge<br>(b) Electric field in the absence of free charge<br>(c) Magnetic field around a current-carrying wire<br>(d) Current density in a conductor | 1 | K1 | CO2 |

8. Capacitance is defined as *1 K1 CO2*
(a) the rate of charge flow across a surface
(b) the potential difference per unit charge
(c) the ability of a system to store an electric charge
(d) the resistance to electric field penetration

9. What is the direction of the magnetic field at the center of a circular current-carrying loop? *1 K1 CO3*
(a) Tangential to the loop
(b) Radial to the loop
(c) Perpendicular to the plane of the loop
(d) Parallel to the plane of the loop

10. What does magnetic force on a current-carrying conductor depend on? *1 K1 CO3*
(a) Only the current through the conductor
(b) Only the magnetic field around the conductor
(c) Both the current and the magnetic field
(d) Neither the current nor the magnetic field

11. What does the Lorentz force law describe? *1 K1 CO3*
(a) The force on a magnetic field due to a current
(b) The force on a charged particle due to electric and magnetic fields
(c) The force between two magnetic poles
(d) The resistance in a magnetic circuit

12. How does the magnetic field due to an infinite sheet of current behave at a distance from the sheet? *1 K1 CO3*
(a) It decreases with the square of the distance (b) It remains constant
(c) It increases with the distance (d) It becomes zero

13. How does a transformer work? *1 K1 CO4*
(a) By converting mechanical energy to electrical energy
(b) By using electromagnetic induction to transfer electrical energy between circuits
(c)Through direct electrical connections
(d) By varying the resistance in the circuit

14. Maxwell's equations unified which of the following aspects of physics? *1 K1 CO4*
(a) Electricity and Magnetism
(b) Gravity and Motion
(c) Thermodynamics and Optics
(d) Kinetics and Potential Energy

15. What principle is demonstrated by the operation of an electrical transformer? *1 K1 CO4*
(a) Conservation of energy (b) Conservation of power
(c) Law of electromagnetic induction (d) Principle of relativity

16. What does the integral form of Gauss's Law for magnetism state? *1 K1 CO4*
(a) The total magnetic flux out of any closed surface is zero
(b) The electric flux through a closed surface is proportional to the charge enclosed
(c) The magnetic flux through a surface is proportional to the surface area
(d) Magnetic fields are always conserved

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| 17. | What defines the propagation constant of a wave?<br>(a) The rate at which the wave's amplitude increases<br>(b) The rate at which the wave's amplitude decreases<br>(c) The phase shift per unit length<br>(d) The frequency shift per unit length | *1* | *K1* | *CO5* |
| 18. | What does the Poynting vector represent?<br>(a) The rate of energy transfer per unit area<br>(b) The magnetic field intensity<br>(c) The electric field strength<br>(d) The impedance of the medium | *1* | *K1* | *CO5* |
| 19. | What is the typical intrinsic impedance of a good conductor?<br>(a) Very high (b) Very low (c) Equal to free space (d) Infinite | *1* | *K1* | *CO5* |
| 20. | What is the characteristic of electromagnetic waves in lossless dielectrics?<br>(a) No energy loss as they propagate (b) Energy is absorbed as heat<br>(c) Partial reflection at interfaces (d) Total internal reflection | *1* | *K1* | *CO5* |

**PART - B (10 × 2 = 20 Marks)**

Answer ALL Questions

| | | | | |
|---|---|---|---|---|
| 21. | State the conditions for a vector A to be (i) solenoidal (ii) irrotational. | *2* | *K1* | *CO1* |
| 22. | What is del operator? How it is used in density curl, gradient and divergence? | *2* | *K1* | *CO1* |
| 23. | What is dielectric strength? | *2* | *K1* | *CO2* |
| 24. | Define electrical potential. | *2* | *K1* | *CO2* |
| 25. | State Ampere's circuital law. | *2* | *K1* | *CO3* |
| 26. | Define magnetic dipole. | *2* | *K1* | *CO3* |
| 27. | Define self inductance. | *2* | *K1* | *CO4* |
| 28. | State Lenz's law. | *2* | *K1* | *CO4* |
| 29. | Point out the difference between attenuation constant and phase constant. | *2* | *K2* | *CO5* |
| 30. | Infer skin depth. | *2* | *K2* | *CO5* |

**PART - C (6 × 10 = 60 Marks)**

Answer ALL Questions

| | | | | | |
|---|---|---|---|---|---|
| 31. | a) | Using divergence theorem, evaluate $\iint F.n\ ds$ where $F = 2xy\ \overrightarrow{a_x} + y^2\overrightarrow{a_y} + 4yz\overrightarrow{a_z}$ and S is the surface of the cube bounded by x=0, x=1; y=0, y=1; and z=0, z=1. | *10* | *K2* | *CO1* |
| | | **OR** | | | |
| | b) | Derive the electric field intensity at the given point due to line charge of finite length. | *10* | *K2* | *CO1* |
| 32. | a) | At an interface separating dielectric medium 1($\varepsilon_{r1}$) and dielectric medium 2($\varepsilon_{r2}$), apply boundary conditions and show that the tangential component of E is continuous across the boundary, whereas the normal component of D is discontinuous at the boundary. | *10* | *K3* | *CO2* |

**OR**

b) Obtain the expression for energy stored and energy density in electrostatic field. *10 K3 CO2*

33. a) Derive an expression for the magnetic field intensity at any point on the line through the centre at a distance 'h' from the centre and perpendicular to the plane of a circular loop of radius 'a' and carrying current 'I'. *10 K2 CO3*

**OR**

b) A very long solenoid with 2*2 cm cross section has an iron core ($\mu_r$=1000) and 4000 turns/meter. If it carries a current of 500 mA, find (i) Its self-inductance per meter (ii) The energy per meter stored in its field. *10 K2 CO3*

34. a) Derive the Maxwell's equations for free space in both integral and point forms, and explain. *10 K2 CO4*

**OR**

b) Derive the expression for the relationship between circuit theory and field theory for a series RLC circuit. *10 K2 CO4*

35. a) State Poynting theorem and thus obtain an expression for an instantaneous power density vector associated with the electromagnetic field. *10 K3 CO5*

**OR**

b) Calculate the intrinsic impedance, the propagation constant and wave velocity for a conducting medium in which $\sigma$ = 58 MS/m, $\mu_r$ = 1, $\varepsilon_r$ = 1 at a frequency of 100 MHz. *10 K3 CO5*

36. a) i) A parallel-plate capacitor with plate area of 5 $cm^2$ and plate separation of 3 mm has a voltage $50\sin 10^3 t$ V applied to its plates. Calculate the displacement current assuming $\varepsilon = 2\varepsilon_0$. *5 K2 CO4*

ii) Outline the general electromagnetic wave equations in terms of electric field. *5 K2 CO5*

**OR**

b) i) Write a short note on "Transformer EMF and Motional EMF". *5 K2 CO4*

ii) Show that the intrinsic impedance for free space is 120π. Derive the necessary equation. *5 K2 CO5*