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M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2025.

Fourth Semester

Physics – Core

ELECTROMAGNETIC THEORY

(For those who joined in July 2023 onwards)

Time : Three hours

Maximum : 75 marks

PART A — (15 × 1 = 15 marks)

Answer ALL questions.

Choose the correct answer :

1. A boundary value problem for the Laplace equation requires:
 - (a) The value of the function at a single point
 - (b) The value of the function on the boundary of the domain
 - (c) The value of the function at infinity
 - (d) The value of the function at the center of the domain

2. The Laplace equation in two dimensions is given by:

(a) $\partial^2 u / \partial x^2 + \partial^2 u / \partial y^2 = 0$

(b) $\partial^2 u / \partial x^2 - \partial^2 u / \partial y^2 = 0$

(c) $\partial u / \partial x + \partial u / \partial y = 0$

(d) $\partial^2 u / \partial x^2 + \partial^2 u / \partial y^2 = 1$

3. Which of the following is a common method for solving the Laplace equation with given boundary conditions?

(a) Fourier series

(b) Laplace transforms

(c) Separation of variables

(d) All of the above

4. The coercivity of a material is:

(a) the magnetic field required to demagnetize the material

(b) a measure of the materials resistance to demagnetization

(c) both (a) and (b)

(d) none of the above

5. The magnetic hysteresis loop:
 - (a) shows the relationship between the magnetic field and the magnetization of a material
 - (b) is used to determine the coercivity and retentivity of a material
 - (c) both (a) and (b)
 - (d) none of the above
6. The relative permeability of a material is:
 - (a) the ratio of the permeability of the material to the permeability of free space
 - (b) a dimensionless quantity
 - (c) both (a) and (b)
 - (d) none of the above
7. What fundamental concept did Maxwell's equations unify?
 - (a) Electricity and magnetism
 - (b) Space and time
 - (c) Energy and matter
 - (d) Gravity and electromagnetism

8. The cutoff frequency of a rectangular waveguide depends on:
 - (a) The dimensions of the waveguide
 - (b) The dielectric material filling the waveguide
 - (c) The mode of propagation
 - (d) All of the above
9. The dominant mode in a rectangular waveguide is the mode with the:
 - (a) Highest cutoff frequency
 - (b) Lowest cutoff frequency
 - (c) Highest wavelength
 - (d) Lowest wavelength
10. Which of the following modes can propagate in a rectangular waveguide?
 - (a) TEM
 - (b) TM
 - (c) TE
 - (d) Both TM and TE
11. What is the primary restoring force for Alfvén waves?
 - (a) Magnetic tension
 - (b) Fluid pressure
 - (c) Gravity
 - (d) Surface tension

12. Which of the following is NOT a type of MHD wave?

- (a) Alfvén waves
- (b) Magnetosonic waves
- (c) Langmuir waves
- (d) Slow waves

13. What are Magnetohydrodynamic (MHD) waves?

- (a) Electromagnetic waves propagating through a conducting fluid
- (b) Sound waves propagating through a magnetic field
- (c) Gravity waves propagating through a plasma
- (d) Surface waves propagating along a fluid-vacuum interface

14. The Boltzmann equation is a cornerstone of:

- (a) Classical mechanics
- (b) Statistical mechanics
- (c) Quantum mechanics
- (d) Thermodynamics

15. The Boltzmann equation can be used to study:

- (a) Rarefied gas flows
- (b) Plasma physics
- (c) Neutron transport
- (d) All of the above

PART B — ($5 \times 4 = 20$ marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

16. (a) State and prove uniqueness theorem.

Or

(b) Derive an expression for electrostatic energy in dielectric media.

17. (a) State and explain Ampere's law in magnetostatics.

Or

(b) Find the vector potential of an infinite solenoid with n turns per length, radius R and current I .

18. (a) State and explain Faraday's laws of electromagnetic induction.

Or

- (b) Discuss in detail Gauge invariance.

19. (a) Explain the plane waves in non-conducting media.

Or

- (b) Obtain the inhomogeneous wave equation and retarded potentials.

20. (a) Derive the Boltzmann equation.

Or

- (b) Explain the plasma confinement in a magnetic field.

PART C — ($5 \times 8 = 40$ marks)

Answer ALL questions, choosing either (a) or (b)
Each answer should not exceed 600 words.

21. (a) Obtain the solution of Laplace equation in cartesian coordinates.

Or

- (b) Discuss about molecular polarizability and electric susceptibility.

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22. (a) Discuss about magnetostatic energy.

Or

- (b) Explain the magnetic induction and magnetic field in macroscopic media.

23. (a) Derive Maxwell's wave equations.

Or

- (b) State and explain Poynting's theorem.

24. (a) Discuss about radiation from a localised source.

Or

- (b) Explain the propagation of TE waves in a rectangular wave guide and hence obtain an expression for cutoff frequency and group velocity.

25. (a) Obtain the simplified magneto hydrodynamic equations.

Or

- (b) Explain the Alfvén waves and magneto sonic waves.

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