(AUTONOMOUS)

**MSc DEGREE EXAMINATION MAY 2026**

(Fourth Semester)

Branch -**PHYSICS**

**PROBLEMS IN CORE PHYSICS**

Time: Three Hours Maximum: 75 Marks

**SECTION-A (10 Marks)**

Answer **ALL** questions

**ALL** questions carry **EQUAL** marks (10 × 1 = 10)

| Module No. | Question No. | Question | K Level | CO |
|---|---|---|---|---|
| 1 | 1 | Which of the following is true regarding the divergence of a curl of any vector field?<br>(i) It is always zero (ii) It is always one<br>(iii) It depends on the field (iv) It is equal to the gradient | K1 | CO1 |
| | 2 | A vector field whose curl is zero is said to be:<br>(i) Solenoidal (ii) Irrotational<br>(iii) Rotational (iv) Divergent | K2 | CO1 |
| 2 | 3 | For any square matrix, the sum of its eigenvalues is equal to its:<br>(i) Determinant (ii) Rank<br>(iii) Trace (iv) Order | K1 | CO2 |
| | 4 | Which theorem is commonly used to find the inverse and powers of a matrix?<br>(i) Gauss-Jordan theorem (ii) Cayley-Hamilton theorem<br>(iii) Taylor's theorem (iv) Stokes' theorem. | K2 | CO2 |
| 3 | 5 | The eigenvalues of Hermitian operators are always:<br>(i) Complex (ii) Imaginary<br>(iii) Real (iv) Zero | K1 | CO3 |
| | 6 | The ground state energy of a quantum mechanical harmonic oscillator is<br>(i) 0 (ii) $\hbar\omega$ (iii) (1/2) $\hbar\omega$ (iv) 2 $\hbar\omega$ | K2 | CO3 |
| 4 | 7 | According to the second law of thermodynamics, the entropy of an isolated system<br>(i) Always decreases (ii) Remains constant<br>(iii) Can never decrease (iv) Is always zero | K1 | CO4 |
| | 8 | Which thermodynamic potential determines the spontaneity of a reaction at constant T and P?<br>(i) Entropy (ii) Gibbs free energy<br>(iii) Internal energy (iv) Enthalpy | K2 | CO4 |
| 5 | 9 | Pure rotational spectra of molecules are typically observed in the<br>(i) Ultraviolet region (ii) X-ray region<br>(iii) Infrared region (iv) Microwave region | K1 | CO5 |
| | 10 | The Born-Oppenheimer approximation assumes that the motion of<br>(i) Nuclei and electrons can be separated<br>(ii) Electrons is faster than light<br>(iii) Nuclei is negligible<br>(iv) All particles move at the same speed | K2 | CO5 |

Cont...

## SECTION - B (35 Marks)

Answer **ALL** questions

**ALL** questions carry **EQUAL** Marks (5 × 7 = 35)

| Module No. | Question No. | Question | K Level | CO |
|---|---|---|---|---|
| 1 | 11.a. | Explain the step-by-step process to construct a Lagrangian for a simple pendulum system and derive its equations of motion. | K2 | CO1 |
| | | (OR) | | |
| | 11.b. | State and prove the Gauss Divergence Theorem and provide one physical application of divergence in fluid dynamics. | | |
| 2 | 12.a. | Explain the physical significance of eigenvalues and eigenvectors in the context of principal axes of rotation for a rigid body. | K4 | CO2 |
| | | (OR) | | |
| | 12.b. | Derive and solve the secular equation for a system of two coupled oscillators to find the normal modes of vibration. | | |
| 3 | 13.a. | Define a normalized wave function and calculate the normalization constant for a particle in a one-dimensional box of length . | K5 | CO3 |
| | | (OR) | | |
| | 13.b. | Describe the quantum mechanical treatment of a linear harmonic oscillator. | | |
| 4 | 14.a. | Derive the four Maxwell's thermodynamic relations using the fundamental thermodynamic potentials (Internal Energy, Enthalpy, etc.). | K3 | CO4 |
| | | (OR) | | |
| | 14.b. | Compare and contrast Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics, highlighting the types of particles they describe. | | |
| 5 | 15.a. | Explain the L-S and J-J coupling schemes used in atomic physics to determine the total angular momentum of multi-electron atoms. | K3 | CO5 |
| | | (OR) | | |
| | 15.b. | Describe the origin of rotational spectra for a diatomic molecule and derive the expression for its rotational energy levels. | | |

## SECTION -C (30 Marks)

Answer **ANY THREE** questions

**ALL** questions carry **EQUAL** Marks (3 × 10 = 30)

| Module No. | Question No. | Question | K Level | CO |
|---|---|---|---|---|
| 1 | 16 | Construct the Lagrangian for a simple harmonic oscillator and use it to derive the Euler-Lagrange equations of motion. | K5 | CO1 |
| 2 | 17 | Derive the first-order correction to energy eigenvalues for a non-degenerate system. | K3 | CO2 |
| 3 | 18 | Solve the Schrödinger equation for a particle in a 1D rigid box. Derive the normalized wavefunctions and the quantized energy eigenvalues. | K4 | CO3 |
| 4 | 19 | Derive any two Maxwell's thermodynamical relations and explain their applications in understanding material properties. | K2 | CO4 |
| 5 | 20 | Discuss the principles of vibrational and rotational spectra in molecules, including the selection rules and energy levels. | K3 | CO5 |

Z-Z-Z END