Name: **Enrolment No:**	

UPES

End Semester Examination, December 2024

Course: Quantum Mechanics and Application **Semester: V**

Program: BSc (H) Physics **Time : 03 hrs.**

Course Code: PHYS 3019 **Max. Marks: 100**

Instructions: Answers should be clearly marked by drawing a box around them.
There should be a clear separation between problems on the same page.
Use pictures/diagrams in solutions whenever you think it is needed.
Scientific calculators are allowed.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	What are the properties of an acceptable wave function for a quantum-sized entity?	**4**	**CO1**
Q 2	Differentiate between normal and anomalous Zeeman effect using suitable examples.	**4**	**CO4**
Q 3	What are the possible z components of the vector $\vec{L}$ that represents the orbital angular momentum of a state with $l = 2$? Compute the magnitude (length) of the angular momentum.	**4**	**CO2**
Q 4	In a Stern–Gerlach experiment, a collimated beam of neutral atoms is split into 7 equally spaced lines. What is the total angular momentum of the atom?	**4**	**CO3**
Q 5	A sphere of radius R and uniformly charges with charge Q is rotating about its own axis with frequency F. Find the magnetic moment of sphere.	**4**	**CO4**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	For spectroscopic transitions, explain Hund's rules with one suitable example.	**10**	**CO4**
Q 7	Show that for a simple harmonic oscillator in the ground states the probability of finding the particle in the classical forbidden region is approximately 16%.	**10**	**CO3**
Q 8	Using Uncertainty principle, estimate the ground state energy (eV) of hydrogen atom. **Or** Using Uncertainty principle, estimate the ground state energy of 1D linear harmonic oscillator.	**10**	**CO1**

Q 9	Show that an electron in a classical circular orbit of angular momentum $\boldsymbol{L}$ around a nucleus has magnetic dipole moment given by $\boldsymbol{\mu} = -\, {e\boldsymbol{L}}/{2m_e}$.	**10**	**CO2**
SECTION-C (2Qx20M=40 Marks)			
Q 10	The ground state of chlorine is $^2P_{3/2}$. Find its magnetic moment. How many substates will the ground state split in a weak applied magnetic field. **Or** Illustrate with the help of diagrams the splitting of $^2D_{5/2}$ and $^2D_{3/2}$ levels of sodium in a weak and strong magnetic field.	**20**	**CO4**
Q 11	Prove that the operator L_z in the spherical polar coordinate system (r, θ, ϕ) is represented by $L_z = -i\hbar\frac{\partial}{\partial\phi}$	**20**	**CO3**

Standard Physics Constants and their values:

Constants	Standard values
Planck's constant (h)	$6.626 \times 10^{-34}\, Js$
Speed of light (c)	$3 \times 10^{8}\ m/s$
Boltzmann constant (k_B)	$1.38 \times 10^{-23}\ J/K$
Rest mass of an electron (m_0)	$9.11 \times 10^{-31}\, kg$ or 511 keV/c^2
Charge on electron (e)	$1.6 \times 10^{-19}\, C$
Rest mass of a proton (m_P)	$1.67 \times 10^{-27}\, kg$