STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086
(For candidates admitted from the academic year 2023 – 2024 and thereafter)

M.Sc. DEGREE EXAMINATION, NOVEMBER 2024
BRANCH III - PHYSICS
THIRD SEMESTER

COURSE   **: MAJOR CORE**
PAPER   **: QUANTUM MECHANICS I**
SUBJECT CODE: 23PH /PC/QM34
TIME   **: 3 HOURS**   **MAX. MARKS: 100**

Q. No.	SECTION A Answer ALL Questions (10 x 3 = 30 marks)	CO	KL
1	What are the conditions that the wave function must obey?	CO1	K1
2	Write the general wave function of a harmonic oscillator.	CO1	K1
3	State Stark effect.	CO1	K1
4	What are ladder operators? Why are they called so?	CO2	K1
5	When do you say two functions are orthonormal?	CO2	K2
6	Are the rigid rotator energy levels degenerate? Explain.	CO2	K2
7	Explain the variational principle.	CO2	K2
8	State the commutation relations obeyed by the components of angular momentum and express them in vector notation.	CO3	K2
9	Illustrate the scattering amplitude.	CO3	K3
10	Explain partial waves.	CO3	K3
Q. No.	SECTION B (8 x 5 = 40 marks)	CO	KL
	PART A **Answer any TWO Questions** **(2 x 5 = 10)**		
11	Show that the zero point energy of ½ ℏω of a linear harmonic oscillator is a manifestation of the uncertainty principle.	CO3	K3
12	A rigid rotator is constrained to rotate about a fixed axis. Find out its normalized eigenfunctions and eigenvalues.	CO3	K3
13	Obtain the energy levels of a symmetric top molecule with principal moments of inertia $I_1 = I_2 = I \neq I_3$	CO3	K3
	PART B **Answer any SIX Questions** **(6 x 5 = 30)**		
14	In a one-dimensional crystal, the periodicity of the potential led to the concept of energy bands-Explain.	CO4	K4
15	Examine the hydrogen atom problem in detail and find its energy level.	CO4	K4
16	Explain the need for WKB approximation.	CO4	K4
17	How many angular momentum states arise for a system with two angular momenta $j_1 = 1$ and $j_2 = 1/2$	CO4	K4
18	Derive an expression for scattering length of a square well potential.	CO4	K4
19	Describe the precession of electron in a magnetic field.	CO4	K4
20	State the eigenvalue – eigenvector relations for the operators J^2 and J_z.	CO4	K4
21	Explain Clebsh – Gordan coefficients with their significance.	CO4	K4

Q. No.	SECTION C **Answer any TWO Questions** **(2x15=30 marks)**	CO	KL
22	Write the Schrodinger equation and the form of the wave function in the different regions of a square well with finite depth.	**CO5**	**K5**
23	Formulate perturbation theory for degenerate levels and apply it to explain the Stark effect in the n=2 level of the Hydrogen atom. Point out the effect of perturbation on the degeneracy of the state.	**CO5**	**K5**
24	Explain a method used to calculate the scattering differential cross section and Born approximation.	**CO5**	**K5**
25	Solve the Eigenvalue problem for the one-dimensional quantum harmonic oscillator.	**CO5**	**K5**

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