Sanjay Ghodawat University, Kolhapur **2018-19**

Established as State Private University under Govt. of Maharashtra. Act No XL, 2017 EXM/P/09/00

Year and Program M.Sc. I **School of Science** **Physics**

Course Code: PHS 501 **Course Title: Quantum Mechanics** **Semester – Odd (I)**

Day and Date: **End Semester Examination** **Time: 2.5 hrs, Max Marks:80**

Instructions:
1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Neat diagrams must be drawn wherever necessary.
4) Use of logarithmic table and calculator are allowed.

		Marks (16)	Blooms Level	CO
Q.2	**Answer the following questions**			
a)	Explain the sequential Stern-Garlach experiment and discuss its analogy with polarized light.	12	L5	501.1
b)	Derive the de-Broglie wavelength equation.	4	L3	501.1
	OR			
b)	Derive the Heisenberg uncertainty principle.	4	L3	501.1
Q.3	**Answer the following questions**	**(16)**		
a)	Discuss the characteristics of one-dimensional motion.	12	L5	501.2
b)	Write a note on the Schwaz inequality.	4	L2	501.2
	OR			
b)	Consider the state $\lvert\psi\rangle = 3i\,\lvert\phi_1\rangle - 7i\,\lvert\phi_2\rangle$, and $\lvert\gamma\rangle = -\lvert\phi_1\rangle + 2i\,\lvert\phi_2\rangle$ where $\lvert\phi_1\rangle$ and $\lvert\phi_2\rangle$ are orthonormal. Show that the state $\lvert\psi\rangle$ and $\lvert\gamma\rangle$ satisfy the triangle inequality.	4	L2	501.2
Q.4	**Answer the following questions**	**(24)**		
a)	Find the energy eigenvalue of a harmonic oscillator using the algebraic method.	16	L5	501.3
b)	Discuss geometrical representation of the angular momentum.	8	L4	501.3

OR

	b)	Use the matrices of $\hat{J}_x$, $\hat{J}_y$ and $\hat{J}_z$ for case $j = 1$ and calculate $[\hat{J}_x, \hat{J}_y]$, $[\hat{J}_y, \hat{J}_z]$, $[\hat{J}_z, \hat{J}_x]$	8	L4	501.3
Q.5		**Answer the following questions**	**(24)**		
	a)	Explain the time independent perturbation theory in non-degenerate case and find the energy correction for first order.	12	L5	501.4
	b)	i) Discuss the importance of the time-independent perturbation theory	4	L3	501.4
		ii) A particle of charge q and mass m, which is moving in a one-dimentional harmonic potential of frequency ω, is subject to a weak electric field ϵ in the x-direction. Find the exact expression for the energy.	8	L4	501.4
		OR			
		ii) Study the effect of an external uniform weak electric field, which is directed along the positive z-axis, $\vec{\varepsilon} = \varepsilon\vec{k}$, on the ground state of a hydrogen atom; ignore the spin degree of freedom. Find an approximate value for the polarizability of the hydrogen atom.	8	L4	501.4

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Course Code: PHS 501 **Course Title: Quantum Mechanics** **Semester – Odd (I)**

Day and Date: Monday 26 Nov 18 **End Semester Examination** **Time: 30 min, Max Marks:20** 10:00 to 1:00pm

Seat No. **PRN No.** **Student Sign.**

Invigilator Sign. **Examiner Sign.** **Marks Obtained**

Instructions: 1) All Questions are compulsory.
2) Mark √ to the correct option. Do not circle.
3) More than one option marked will not be considered for assessment.
4) Rough calculations on paper are not allowed.
5) Use non-programmable calculator is allowed.

Q.1	Attempt the following	(Marks 20)	Blooms Level	CO
A)	**Choose the correct alternative.**	(10)		
1	The uncertainty relation is only applicable for.....	1	L1	501.1
	A) Classical particles **B)** Quantum particles			
	C) Energetic particles **D)** All of these			
2	The $S_y \pm$ state can be explained by .....polarized light.	1	L1	501.1
	A) Linear **B)** Circular **C)** Elliptical **D)** Anti linear			
3	For which condition a matrix A is a skew symmetric matrix.....	1	L1	501.2
	A) A^T **B)** A^* **C)** A^{-T} **D)** $-A^T$			
4	.....is the boundary condition for potential step $V(x) = V_0$.	1	L1	501.2
	A) $x \geq 0$ **B)** $x \leq 0$ **C)** $x > 0$ **D)** $x < 0$			
5	For discrete spectrum, the motion of particle bounded between	1	L1	501.3

A) $E > V_{min}$ B) $E < V_{max}$ C) $V_{min} < E < V$ D) $V_{min} > E < V$

6 Operator $\hat{a}$ is non Hermitian dimensionless operator, if $\hat{a}^{\dagger}|n\rangle =$ 1 L1 501.3

A) $\sqrt{n}|n+1\rangle$ B) $\sqrt{n+1}|n+1\rangle$

C) $\sqrt{n+1}|n-1\rangle$ D) $\sqrt{n-1}|n-1\rangle$

7 For harmonic oscillator, zero point energy is 1 L1 501.3

A) $\hbar\omega$ B) $\frac{\hbar\omega}{2}$ C) $2\hbar\omega$ D) $\frac{\hbar\omega}{4}$

8 Time-independent perturbation theory is most suitable when $\hat{H}$ is very close to 1 L1 501.4

A) $\hat{H}_0 + \hat{H}_p$ B) $\hat{H}_0$ C) $\hat{H}_p$ D) None of these

9 For any arbitrary trial function $|\psi\rangle$ the energy is always ..... the exact energy E_0. 1 L1 501.4

A) Equal to B) Less than

C) Greater than or equal to D) Less than or equal to

10 The WKB approximation is valid when the potential will remain constant over the region of the order of 1 L1 501.4

A) Compton wavelength B) de-Broglie wavelength

C) Very small wavelength D) None of these

B) Fill in the blanks (5)

1 .... is known as the Schrodinger wave equation . 1 L1 501.1

2 The quantity $\langle \phi | \phi \rangle$ is a .... number. 1 L1 501.2

3	The Ladder method deals with ....of the operators.	1	L1	501.3
4	If $\hat{J}$ is the angular momentum, then values of j are either integer or	1	L1	501.3
5	In the time-independent perturbation theory $\hat{H}$ can be split into two .....parts.	1	L1	501.4

C) State true or false (5)

1	The Stern- Garlach experiment is originally invented by W. Gerlach.	1	L1	501.1
2	The null ket is represented as $0I\varphi >= 0$.	1	L1	501.2
3	$[\hat{J}_z^2, \hat{J}_x] = 0$.	1	L1	501.3
4	The perturbation theory is used to obtain an exact solution.	1	L1	501.4
5	In the Stark effect, the splitting of energy levels is observed in the presence of weak electric field.	1	L1	501.4