DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY

LESSON PLAN

B.Sc. – THIRD YEAR
(2015-2016 REGULATION)

FIFTH SEMESTER

.

SRM UNIVERSITY

FACULTY OF SCIENCE AND HUMANITIES

SRM NAGAR, KATTANKULATHUR – 603 203

SRM UNIVERSITY
FACULTY OF SCIENCE AND HUMANITIES
DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
Third Year B.Sc Physics (2015-2016 Regulation)

Course Code: UPY15501

Course Title: Quantum Mechanics

Semester: V

Course Time: JUL 2016 – DEC 2017

Location: S.R.M. UNIVERSITY

OBJECTIVES

1. To understand the dual nature of matter wave.
2. To apply the Schrodinger equation to different potential.
3. To understand the Heisenberg Uncertainty Relation and its application.
4. To emphasize the significance of Harmonic Oscillator Potential and Hydrogen atom.

Assessment Details:

Cycle Test – I	:	10 Marks
Cycle Test – II	:	10 Marks
Model Exam	:	20 Marks
Assignments	:	5 Marks
Attendance	:	5 Marks

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Third Year B.Sc Physics (2015-2016 Regulation)

Semester	Course Code	Course Title	L	T	P	Total of LTP	C
II	UPY15501	QUANTUM MECHANICS	4	1	-	5	4

UNIT I - WAVE NATURE OF MATTER

Inadequacy of classical mechanics - Black body radiation - Quantum theory – Photo electric effect -Compton effect -Wave nature of matter-Expressions for de-Broglie wavelength - Davisson and Germer's experiment - G.P. Thomson experiment - Phase and group velocity and relation between them - Wave packet - Heisenberg's uncertainity principle – Its consequences (free electron cannot reside inside the nucleus and gamma ray microscope).

UNIT II - QUANTUM POSTULATES

Basic postulates of quantum mechanics - Schrodinger's equation - Time Independent -Time Dependant - Properties of wave function - Operator formalism – Energy - Momentum and Hamiltonian Operators - Interpretation of Wave Function - Probability Density and Probability - Conditions for Physical Acceptability of Wave Function -. Normalization - Linearity and Superposition Principles - Eigen values and Eigen functions - Expectation Values - Wave Function of a Free Particle.

UNIT III - APPLICATION OF WAVE MECHANICS IN ONE DIMENSION

Free Particle Solution and Plane Wave Normalization - Particle in a box of length L - Energy Eigen value and normalized Eigen function - Barrier penetration problem - Finite potential well - Tunnel effect - Scanning Tunneling Microscope - Harmonic Oscillator wave function - Energy levels - Zero point energy.

UNIT IV - APPLICATION OF WAVE MECHANICS IN THREE DIMENSION

Angular momentum operators and their commutation relations - Eigen values and Eigen functions of L^2 and L_z - Theorem of addition of angular momenta [statement with examples] - The Hydrogen Atom problem - Stationary state wave functions as simultaneous Eigen functions of H, L^2 , and L_z - Radial Schrodinger equationand Energy Eigen values [Laguerre polynomial solutions to be assumed] - Degeneracy of the energy Eigen values.

UNIT V - SPIN ANGULAR MOMENTUM

Electron spin – Stern Gerlach experiment - Orbital angular momentum - Magnetic dipole moment and energy in magnetic field from classical viewpoint - Zeeman effect -spin-orbit coupling - Fine structure - Total angular momentum - Pauli Exclusion Principle - Spin of an electron - Magnetic moment of an electron due to spin - Energy values in a Coulomb potential.

TEXT BOOKS

1. David J. Griffiths, Introduction to Quantum Mechanics, 2 nd Edition, Pearson Publication, 2009.

2. Satya Prakash, Advanced Quantum Mechanics, 5 th Edition, Kedar Nath Ram Nath Publishing Ltd, 2013.

REFERENCES

1. Merzbacher E., Quantum Mechanics, 3rd edition, Wiley Publishing, 1998.
2. Leonard I Schiff, Quantum Mechanics, 3rd Edition, McGraw Hill Book Company, 1968.
3. Thankappan V.K., Quantum Mechanics, 2nd Edition, New Age International (P) Ltd, 1996.
4. Mathews P.M.and Venkatesan K., Quantum Mechanics, Tata McGraw Hill Publishing Ltd,1975
5. Gupta, Kumar and Sharma, Quantum Mechanics, Jai Prakash Nath Company, 2010.

LESSON PLAN

Subject Name:	**QUANTUM MECHANICS**
Subject Code:	**UPY15501**

UNIT I – WAVE NATURE OF MATTER

L+T Hour	**Contents Description**	**References**
1	Inadequacy of classical mechanics	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2
2	Black body radiation	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2.2
3	Quantum theory of light	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 2.2
4	Photo electric effect	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2.3
5	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2
6	Compton effect	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2.7
7	Back-scattering	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2.7
8	Wave nature of matter-Expressions for de-Broglie wavelength	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3.1
9	Davisson and Germer's experiment - G.P. Thomson experiment	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 1.6
10	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 2, 3
11	Phase and group velocity and relation between them	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3.4
12	Wave packet - Heisenberg's uncertainity principle	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3.3,

		3.7, 3.8
13	Free electron cannot reside inside the nucleus and problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3.9
14	Thought Experiment: Gamma ray microscope	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3.9
15	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 3

UNIT II – QUANTUM POSTULATES		
L+T Hour	**Contents Description**	**References**
16	Basic postulates of quantum mechanics	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 5.1-5.3
17	Basic postulates of quantum mechanics	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 5.1-5.3
18	Schrodinger's equation: Time independent	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5.1-5.3, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 1.1
19	Schrodinger's equation: Time dependent	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5.5, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 2.1
20	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5
21	Properties and physical significance of wave function	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5.1-5.6, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 1
22	Operator formalism: Energy, Momentum and Hamiltonian Operators	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5 Appendix, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 3
23	Schrodinger's equation in operator form	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5 Appendix, David Griffiths, *Introduction to Quantum Mechanics*,

		2nd Edition, McGraw Hill, 2009. Chapter 3
24	Interpretation of Wave Function: Probability and Probability Density	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 1.2-1.5
25	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5
26	Conditions for Physical Acceptability of Wave Function: Normalization	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2009. Chapter 5 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 3
27	Linearity and Superposition Principles	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 5.1-5.3
28	Eigen values & Eigen functions, expectation Values	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 5.4 & Appendix, David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapter 3
29	Wave Function of a Free Particle.	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.1 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapters 2.1
30	Problem solving	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009.
•	**CYCLE TEST - I**	**Unit I and II**

Unit III – APPLICATION OF WAVE MECHANICS IN ONE DIMENSION		
L+T Hour	**Description**	**Reference with chapter**
31	Free Particle Solution and Plane Wave Normalization	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.2 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapters 2.1& 2.4
32	Particle in a box	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 3.6 & Appendix
33	Energy Eigen value and normalized Eigen function for particle in a box	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 3.6 & Appendix
34	Barrier penetration problem, introduction to step potentials	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.3, 4.4 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapters 2.5 & 2.6
35	Problem solving	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009.
36	Step potential plane wave solution for case $E<V_0$	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.3
37	Step potential plane wave solution for case $E>V_0$	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.3
38	Finite potential well: Plane wave solution	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.4 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapters 2.5& 2.6
39	Finite potential well: Plane wave solution	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.4 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009. Chapters 2.6
40	Problem solving	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, McGraw Hill, 2009.
41	Tunnel effect	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 4.4
42	Scanning Tunneling	Arthur Beiser, *Concepts of Modern Physics*, 6th

	Microscope	Edition, McGraw Hill, 2008. Chapter 5.8
43	Harmonic Oscillator: wave function	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 5.9
44	HO: Energy levels, zero point energy.	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 5.8
45	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 5
•	**CYCLE TEST-II**	**Unit III and IV**
Unit IV – APPLICATION OF WAVE MECHANICS IN THREE DIMENSION		
L+T Hour	**Description**	**Reference with chapter**
46	Angular momentum operators	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.1- 6.3
47	Angular momentum commutation relations	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.1- 6.3
48	Eigen values and Eigen functions of L^2 and L_z	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.1- 6.3
49	Theorem of addition of angular momenta [statement with examples]	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.4- 6.9 Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7
50	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7
51	Radial Schrodinger equation	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.1-6.2
52	Radial Schrodinger equation	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.1-6.2
52	The Hydrogen Atom problem	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6..1-6.2
53	Hydrogen Atom: Stationary state wave functions	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.2-6.3

54	Hydrogen Atom: Eigen functions of H, L^2 , and L_z	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.4-6.6
55	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.2-6
57	Energy Eigen values [Laguerre polynomial solutions to be assumed]	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, Pearson Publication, 2009. Chapter 4.2
58	Energy Eigen values [Laguerre polynomial solutions to be assumed]	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, Pearson Publication, 2009. Chapter 4.2
59	Degeneracy of the energy Eigen values.	David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, Pearson Publication, 2009. Chapter 4.2
60	Problem solving	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6

Unit V – SPIN ANGULAR MOMENTUM		
L+T Hour	**Description**	**Reference with chapter**
61	Spin of an electron - Magnetic moment of an electron due to spin	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.1
62	Exclusion principal	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.2
63	Stern Gerlach experiment	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.2
64	Symmetric and antisymmetric wave functions	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.3
66	Orbital angular momentum	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.1
67	Magnetic dipole moment and energy in magnetic field from classical viewpoint	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.1 Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.7
68	Spin-orbit coupling	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 7.7
69	Zeeman Effect	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 6.10, 7.7
71	LS coupling and Total angular momentum	Bransden and Joachain, *Quantum Mechanics*, 2nd Edition, McGraw Hill, 2008. Chapter 6.7-6.9
72	Fine structure	Bransden and Joachain, *Quantum Mechanics*, 2nd

		Edition, McGraw Hill, 2008. Chapter 7.5 David Griffiths, *Introduction to Quantum Mechanics*, 2nd Edition, Pearson Publication, 2009. Chapter 6.3
73	Energy values in a Coulomb potential.	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 8
74	Application to Nuclear Physics	Arthur Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw Hill, 2008. Chapter 8
75	Problem Solving	Gupta, Kumar, Sharma, *Quantum Mechanics*, 29th Edition, Jai Prakash Nath & Co, 2010. Chapter 13.9
•	**MODEL EXAMINATION**	**Unit I – V**

Course Coordinator **Head of the Department**

(Dr. Rohit Dhir) **(Dr. C. Preferencial Kala)**