TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

QUANTUM MECHANICS 1

by

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PREFACE

The Quantum Mechanics 1 course is a 4th semester course for students who have finished the Elementary Linear Algebra course, Modern Physics course, Mathematical Methods in Physics 2 course, and the Mathematical Methods in Physics 3 course. For 12 weeks students will receive lecture materials on black body radiation, the photoelectric effect, Compton scattering, wave-particle duality, the Bohr atom, de Broglie waves, the correspondence principle, wave packets, Heisenberg uncertainty principle, Schrödinger's equation, wave functions, probability interpretation, normalization, expected value, operators, commutative property, stationary state, eigenvalue and eigenfunction, linear operator, hermiticity, expansion theorems, free wave normalization, parity, degeneration, Dirac notation, representation, problems with one-dimensional potential, simple harmonic oscillator and ladder operators, changes in expected value over time, time-dependence of operators, the Schrödinger picture and Heisenberg picture, N-particle systems, central force, Schrödinger's equation in three dimensions, angular momentum, hydrogen-like atoms in simple quantum systems, and hydrogen-like atoms.

It is hoped that after finishing the Quantum Mechanics 1 course students will be able to apply fundamental concepts in quantum mechanics on simple quantum systems and atoms such as hydrogen.

Depok, August 2020

Dr. Adam Badra Cahaya

I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Quantum Mechanics 1
3.	Course Code	:	SCFI603119
4.	Semester	:	4
5.	Credit	:	4 credits
6.	Teaching Method(s)	:	Interactive lecture, discussion, and presentation
7.	Prerequisite course(s)	:	Elementary Linear Algebra, Modern Physics, Mathematical Methods in Physics 2, Mathematical Methods in Physics 3
8.	Requisite for course(s)	:	Quantum Mechanics 2, Relativistic Quantum Mechanics, Scattering Theory, Nuclear, and Particle Physics
9.	Integration Between Other Courses	:	-
10.	Lecturer(s)	:	Dr. Adam Badra Cahaya
11.	Course Description	:	Black body radiation, the photoelectric effect, Compton scattering, wave-particle duality, the Bohr atom, de Broglie waves, the correspondence principle, wave packets, Heisenberg uncertainty principle, Schrödinger's equation, wave functions, probability interpretation, normalization, expected value, operators, commutative property, stationary state, eigenvalue and eigenfunction, linear operator, hermiticity, expansion theorems, free wave normalization, parity, degeneration, Dirac notation, representation, problems with one-dimensional potential, simple harmonic oscillator and ladder operators, changes in expected value over time, time-dependence of operators, the Schrödinger picture and Heisenberg picture, N-particle systems, central force, Schrödinger's equation in three dimensions, angular momentum, hydrogen-like atoms in simple quantum systems, and hydrogen-like atoms.

II. Course Learning Outcome (CLO) and Sub-CLOs

A. CLO

After the completion of this course, students will be able to apply fundamental concepts in quantum mechanics to simple quantum systems and atoms such as hydrogen. (C3)

B. Sub-CLO

After the completion of this course, students will be able to:

1. identify (C1) particle-wave duality in a wave function,
2. explain (C2) the concept of the wave function and Schrödinger's equation in the motion of a free particle blocked by a one-dimensional potential,
3. explain (C2) the concept of eigenvalue and the wave function of a bounded particle in one dimension,
4. apply (C3) the concept of operators in harmonic oscillations, angular momentum, and N-particle systems,
5. apply (C3) the concept of the wave function in a hydrogen atom and under a three-dimensional potential.

III. Teaching Plan

Week	Sub-CLO	Study Materials	Teaching Method	Time Required	Learning Experiences (*O-E-F)	Sub-CLO Weight on Course (%)	Sub-CLO Achievement Indicator	References
1	1	Course contract, introduction to the course.	Lecturing	2x50 minutes	30% O, 60% E, 10% F	20	Students can identify the need for the concept of wave-particle duality.	Chapter 1 of the required textbook
2	1	Wave-particle duality	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can identify wave-particle duality.	Chapter 2 of the required textbook
3	1	Heisenberg uncertainty principle	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can identify wave-particle duality in the Heisenberg uncertainty principle.	Chapter 2 of the required textbook
4	2	Schrödinger's equation	Lecturing	2x50 minutes	30% O, 60% E, 10% F	15	Students can explain Schrödinger's equation.	Chapter 3 of the required textbook
5	2	Free particle	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can explain the concept of the wave function of a free particle.	Chapter 4 of the required textbook
6	3	One dimensional potential	Lecturing	2x50 minutes	30% O, 60% E, 10% F	15	Students can explain the concept of the wave function in one dimension.	Chapter 4 of the required textbook
7	3	Harmonic oscillator	Lecturing	2x50 minutes	30% O, 30% E, 10% F		Students can explain the concept of the wave function in a harmonic oscillator.	Chapter 4 of the required textbook

8	**Midterm Exam**							
9	5	Dirac notation	Lecturing	2x50 minutes	30% O, 60% E, 10% F	25	Students can apply the concept of operators.	Chapter 5 of the required textbook
10	4	Operator methods	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can apply the concept of operators in harmonic oscillators.	Chapter 6 of the required textbook
11	4	Angular momentum	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can apply the concept of operators in angular momentum.	Chapter 7 of the required textbook
12	4	Quantum N-particles	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can apply the concept of operators in N-particle systems.	Chapter 13 of the required textbook
13	5	3D Schrödinger's equation	Lecturing	2x50 minutes	30% O, 60% E, 10% F	25	Students can apply the concept of wave functions in a three-dimensional potential.	Chapter 8 of the required textbook
14	5	Central potential	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Students can apply the concept of wave functions in a three-dimensional potential.	Chapter 8 of the required textbook
15	s	Hydrogen atom	Lecturing	2x50 minutes	30% O, 60% E, 10% F		Student can apply the concept of wave function in a hydrogen atom.	Chapter 8 of the required textbook
16	**Final Exam**							

*) O : Orientation
E : Exercise
F : Feedback

References:

1. S. Gasiorowicz, Quantum Physics 3rd Ed., John Wiley & Sons, Inc., 2003.
2. A. Goswami, Quantum Mechanics 2nd Ed., Wm. C. Brown Publishers, 1997.

IV. Assignment Design

Week	Assignment Name	Sub-CLO	Assignment	Scope	Working Procedure	Deadline	Outcome
3	Group Assignment 1	1	Group Assignment	Heisenberg uncertainty principle	Group homework	1 Week	PowerPoint file
5	Individual Assignment 1	2	Essay	The motion of a free particle	Individual homework	1 Week	Graphs and PDF file
6	Individual Assignment 2	3	Essay	One dimensional bound state	Individual homework	1 Week	Graphs and PDF file
12	Group Assignment 2	4	Presentation	Angular momentum and N-particle systems	Group homework	1 Week	PowerPoint file
14	Individual Assignment 3	5	Essay	Central force	Individual homework	1 Week	PDF file

V. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual Assignment	2, 3, 5	Answer sheet	3	30
Group Assignment	1, 4	Presentation	5	20
Midterm Exam	1, 2, 3	Answer sheet	1	25
Final Exam	4, 5	Answer sheet	1	25
Total				**100**

VI. Rubric

A. Criteria of Presentation Score

Score	Presentation Delivery
85-90	Group is able to deliver the explanation logically, fluently, and punctual and be able to answer the questions from other students and lecturer
75-84	Group is able to deliver the explanation logically and fluently and be able to answer the questions from other students and lecturer, but be less punctual on delivering the explanation
65-74	Group is able to deliver the explanation fluently, but be less able to deliver the reasoning logic of the explanation
55-64	Group is less able to deliver the explanation fluently and punctual and be less able to deliver the reasoning logic of the explanation
<55	

B. Criteria of Assignment and Exam Scores

Score	Answer Quality
100	Answer is very precise and all the concept and main component are explained completely
76-99	Answer is fairly precise and the concept and main component are explained fairly complete
51-75	Answer is less precise and the concept and main component are explained less complete
26-50	Answer is poorly precise and the concept and main component are explained poorly complete
<25	Answer is wrong