Semester Lesson Plan (SLP)

	THE STATE UNIVERSITY OF SURABAYA **FACULTY OF MATHEMATICS AND NATURAL SCIENCES** **PHYSICS STUDY PROGRAM**	**Document Code**

SEMESTER LESSON PLAN

NAME OF COURSE	COURSE CODE	DISCIPLINE	COURSE UNIT		SEMESTER	DATE CREATED
QUANTUM PHYSICS	8420304068	PHYSICS	T= 4 units	P=?	5 (five)	4 December 2020

AUTHORISATION	AUTHOR	COURSE COORDINATOR	HEAD OF PHYSICS EDUCATION STUDY PROGRAM
PHYSICS DEPARTMENT	Tjipto Prastowo, Ph.D	Tjipto Prastowo, Ph.D	Prof. Dr. Munasir, M.Si.

Learning Achievement		
	Program Learning Outcome (PLO)	
	PLO-3	Able to solve problems in physical systems comprehensively by using mathematics and computational tools.
	PLO-4	Able to analyze a physical system by applying mathematics and computational tools/ICT.
	PLO-10	Able to demonstrate good scientist's manners, critical thinking and innovation skills in research and professional fields; and willing to do lifelong learning.
	Course Learning Outcome (CLO)	
	CLO-1	Demonstrating independent, creative and honest characters in doing student assignments, mid and final exams.
	CLO-2	Understanding theoretical concepts of quantum physics in general and the Heisenberg uncertainty principle for microscopical systems, and the Schrodinger wave mechanics comprehensively.
	CLO-3	Being able to formulate problem solving for procedural problems related to the applications of concepts of quantum physics with the Heisenberg uncertainty principle and the Schrodinger wave mechanics for reformulation of hydrogen atom and hydrogen-like atoms.
	Final competence in each step of learning (Sub-CLO)	
	Sub-CLO1	Being able to understand black-body radiation, from its phenomenon to an approach of both classical and quantum physics.
	Sub-CLO2	Being able to understand particle properties of electromagnetic waves.
	Sub-CLO3	Being able to understand the development of theory of an atom, spectral analysis of hydrogen atom, the presence of primitive quantum theory for hydrogen atom.
	Sub-CLO4	Being able to understand wave properties of microscopic particles moving at particular speed.

	Sub-CLO5	Being able to understand the nature of microscopic world in the presence of the Heisenberg uncertainty principle.
	Sub-CLO6	Being able to understand basic principles of wave mechanics in the forms of quantum mechanics postulates.
	Sub-CLO7	Being able to understand concepts of wave mechanics, the use of Schrodinger wave equation to solve physics problems related to microscopic world, to derive energy conservation formulation applied to simple potential cases, analytic and algebraic methods for harmonic oscillator.
	Sub-CLO8	Being able to understand complete solutions of the 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), reformulation of hydrogen atom in the spherical coordinate system.
	Sub-CLO9	Being able to understand reformulation of hydrogen atom in the spherical coordinate system, the importance of orbital, spin and total angular momenta for complete description of quantum theory for hydrogen atom.
	Sub-CLO10	Being able to apply concepts of quantum mechanics for physical phenomena associated with spectral analysis of hydrogen and hydrogen-like atoms.
Course Description	Quantum Physics examines the history of quantum concepts from empirical observations to theoretical approaches, the use of the Schrodinger wave mechanics to solve physics problems related to dynamics of microscopic particles with and without external influence of potential field, hydrogen atom theory revisited through complete solutions derived from the 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), the roles of spin-orbit coupling in controlling fine and hyperfine structures, Zeeman and Stark effects.	
Topic Discussions: Learning Materials	1. The history of quantum theory: Black-body radiation, Wien's law, Rayleigh-Jeans law, Plank's quantum concept and Plank's law 2. Particle properties of waves: Photo-electric effect, Compton effect 3. Wave properties of matter: de Broglie hypothesis, implications of de Broglie hypothesis, Davisson-Germer experiment 4. Primitive Quantum Theory: the development of atomic models, Bohr's model for the hydrogen, spectral analysis of the hydrogen, correspondence principle 5. The nature of microscopic world: Heisenberg uncertainty principle, interpretation and consequence of Heisenberg uncertainty principle 6. Mathematical formulation for Quantum Theory: Operators and measurements in quantum mechanics, wave function, Born interpretation, normalisation procedure, superposition principle, expectation value 7. Stationary states, free particle confined in a limited space, simple potential problems, continuity equation and energy conservation in microscopic world, analytic and algebraic methods for harmonic oscillator 8. The 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), hydrogen atom theory revisited 9. Total angular momentum, orbital angular momentum and its corresponding angular motion, spin angular momentum and its corresponding spinning motion 10. Fine and hyperfine structures, relativistic correction, the role of spin and spin-orbit coupling in spectral analysis, Zeeman and Stark effects	
References	**Primary:**	
	1. Prastowo, T. and Rahmawati, E. 2014. Lecture Notes on Quantum Physics. Unpublished work. 2. Zettili, N. 2009. Quantum Mechanics. West Sussex, UK: John Wiley and Sons. 3. Grifftiths, D. J. 1995. Introduction to Quantum Mechanics. New Jersey, US: Prentice-Hall. 4. Gasiorowicz, S. 1996. Quantum Physics. New York, US: John Wiley and Sons.	

	5. Liboff, R. 1980. Introductory Quantum Mechanics. Reading, US: Addison-Wesley. 6. McMahon, D. 2005. Quantum Mechanics demystified. New York, US: McGraw-Hill.
	Secondary:
	Some power point files and/or course materials relevant to Quantum Physics from the internet
Lecturers	1. Tjipto Prastowo, Ph.D. 2. Utama Alan Deta, M.Pd., M.Si.
Pre-requisites	Modern Physics

Week	**Final competence in each learning step (Sub-CLO)**	**Assessment**		**Learning Format, Methods, Instruction, (Time Allocation)**		**Learning Materials**	**Proportion (%)**
		Indicator	**Criteria & Format**	**Luring (*offline*)**	**Daring (*online*)**		
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
1	Being able to understand black-body radiation, from its phenomenon to an approach of both classical and quantum physics	Students can explain black-body radiation, from its phenomenon to an approach of both classical and quantum physics; solve relevant problems	Exercise on Chap. 1, Lecture Notes on Quantum Physics (Assignment 1)		Contextual Learning Class discussion Q & A	• Black-body radiation • Wien's law • Rayleigh-Jeans law • Plank's quantum concept • Plank's law	**5%**
2	Being able to understand particle properties of electromagnetic waves	Being able to understand particle properties of electromagnetic waves; solve relevant problems	Exercise on Chap. 2, Lecture Notes on Quantum Physics (Assignment 2)		Contextual Learning Class discussion Q & A	• Particle properties of waves • Photo-electric effect • Compton effect	**5%**
3	Being able to understand	Being able to	Exercise on Chap. 3,		Contextual Learning	• Wave properties of	**5%**

	the development of theory of an atom, spectral analysis of hydrogen atom, the presence of primitive quantum theory for hydrogen atom	understand the development of theory of an atom, spectral analysis of hydrogen atom, the presence of primitive quantum theory for hydrogen atom; solve relevant problems	Lecture Notes on Quantum Physics (Assignment 3)		Class discussion Q & A	matter • de Broglie hypothesis • implications of de Broglie hypothesis • Davisson-Germer experiment	
4	Being able to understand wave properties of microscopic particles moving at particular speed	Students can explain Being able to understand wave properties of microscopic particles moving at particular speed; solve relevant problems	Exercise on Chap. 4, Lecture Notes on Quantum Physics (Assignment 4)		Contextual Learning Class discussion Q & A	• Primitive Quantum Theory • The development of atomic models • Bohr's model for the hydrogen • Spectral analysis of the hydrogen • Correspondence principle	**5%**
5	Being able to understand the nature of microscopic world in the presence of the Heisenberg uncertainty principle	Students can explain Being able to understand the nature of microscopic world in the presence of the Heisenberg uncertainty	Exercise on Chap. 5, Lecture Notes on Quantum Physics (Assignment 5)		Contextual Learning Class discussion Q & A	• The nature of microscopic world • Heisenberg uncertainty principle • Interpretation and consequence of Heisenberg uncertainty principle	**5%**

		principle; solve relevant problems					
6	Being able to understand basic principles of wave mechanics in the forms of quantum mechanics postulates	Students can explain basic principles of wave mechanics in the forms of quantum mechanics postulates			Contextual Learning Class discussion Q & A	• Mathematical formulation for Quantum Theory • Operators and measurements in quantum mechanics • Wave function • Born interpretation • Normalisation procedure • Superposition principle • Expectation value	
7	Being able to understand concepts of wave mechanics, the use of Schrodinger wave equation to solve physics problems in microscopic world, to derive energy conservation formulation applied to simple potential cases	Students can explain concepts of wave mechanics, the use of Schrodinger wave equation to solve physics problems in microscopic world, to derive energy conservation formulation applied to			Contextual Learning Class discussion Q & A	• Stationary states • Free particle confined in a limited space • Simple potential problems • Continuity equation and energy conservation in microscopic world • Harmonic oscillator	

		simple potential					
8	**Mid Semester Exam**						**30%**
9	Being able to understand concepts of wave mechanics, the use of Schrodinger wave equation to solve physics problems in microscopic world, to derive energy conservation formulation applied to simple potential cases, to understand analytic and algebraic methods for harmonic oscillator	Students can explain concepts of wave mechanics, the use of Schrodinger wave equation to solve physics problems in microscopic world, derive energy conservation formulation applied to simple potential, use analytic and algebraic methods for harmonic oscillator			Contextual Learning Class discussion Q & A	• Stationary states • Free particle confined in a limited space • Simple potential problems • Continuity equation and energy conservation in microscopic world • Harmonic oscillator	
10	Being able to understand complete solutions of the 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), reformulation of hydrogen atom in the spherical coordinate system	Students can explain complete solutions of the 3D Schrodinger wave equation in the spherical coordinate system (radial			Contextual Learning Class discussion Q & A	• The 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components) • Hydrogen atom theory revisited	

		and angular components), reformulation of hydrogen atom in the spherical coordinate system					
11	Being able to understand complete solutions of the 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), reformulation of hydrogen atom in the spherical coordinate system	Students can explain complete solutions of the 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components), reformulation of hydrogen atom in the spherical coordinate system	Exercises on Chap. 6 & 7, Lecture Notes on Quantum Physics (Assignment 6)		Contextual Learning Class discussion Q & A	• The 3D Schrodinger wave equation in the spherical coordinate system (radial and angular components) • Hydrogen atom theory revisited	**5%**
12	Being able to understand reformulation of hydrogen atom in the spherical coordinate system, the importance of orbital, spin and total angular momenta for complete description of quantum theory for hydrogen atom	Students can explain reformulation of hydrogen atom in the spherical coordinate system, the importance of orbital, spin and total angular momenta for			Contextual Learning Class discussion Q & A	• Total angular momentum • Orbital angular momentum and its corresponding angular motion • Spin angular momentum and its corresponding spinning motion	

		complete description of quantum theory for hydrogen atom					
13	Being able to understand reformulation of hydrogen atom in the spherical coordinate system, the importance of orbital, spin and total angular momenta for complete description of quantum theory for hydrogen atom	Students can explain reformulation of hydrogen atom in the spherical coordinate system, the importance of orbital, spin and total angular momenta for complete description of quantum theory for hydrogen atom			Contextual Learning Class discussion Q & A	• Total angular momentum • Orbital angular momentum and its corresponding angular motion • Spin angular momentum and its corresponding spinning motion	
14	Being able to apply concepts of quantum mechanics to physical phenomena associated with spectral analysis of hydrogen and hydrogen-like atoms	Students can explain concepts of quantum mechanics to physical phenomena associated with spectral analysis of hydrogen and hydrogen-like atoms			Contextual Learning Class discussion Q & A	• Fine and hyperfine structures • Relativistic correction • The role of spin and spin-orbit coupling in spectral analysis • Zeeman effect • Stark effect	
15	Being able to apply concepts	Students can			Contextual Learning	• Fine and hyperfine	

	of quantum mechanics to physical phenomena associated with spectral analysis of hydrogen and hydrogen-like atoms	explain concepts of quantum mechanics to physical phenomena associated with spectral analysis of hydrogen and hydrogen-like atoms			Class discussion Q & A	structures • Relativistic correction • The role of spin and spin-orbit coupling in spectral analysis • Zeeman effect • Stark effect	
16	**Final Exam**						**40%**