SEMESTER LEARNING ACTIVITY PLANS (SLAP)

SEMESTER EVEN 2022/2023

Physics Undergraduate Study Program

Physics Department

Quantum Physics II

MFF 2035/ 3 Credits

Lecturer Coordinator:

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UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
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Code	Course Name	Credits (Credits)		Semester	Status	Prerequisite
MFF 2035	*Quantum Physics II*	*T: 3*	*P: …*	*EVEN*	*Compulsory*	*Quantum Physics I (MFF2034)*
Short Description	The Quantum Physics II course is a continuation of the Quantum Physics I course, both of which cover the topic or study of Quantum Mechanics. Quantum mechanics is a field of physics that studies physical phenomena on a microscopic scale. Due to such a small system size in the microscopic system, some physical phenomena that occur naturally in it will, at first glance, seem odd according to everyday understanding. The word quantum in terms of Quantum Mechanics is an example of one of the physical phenomena that seems odd, namely the change of several physical quantities from a continuous (malar) state in a macroscopic system to a discrete (quantized) state when in a microscopic system. Looking back on the early developments of quantum mechanics in the early 20th century, Max Planck thoroughly explained the blackbody radiation spectrum when assuming that light consists of quantizing physical quantities in the form of energy packets. Several other physical phenomena can only be explained by observing this type of Max-Planck, including those that occur in the photoelectric and Compton effects. Another odd phenomenon in microscopic systems that is quite popular is the application of Heisenberg's uncertainty principle. In this principle, several pairs of physical quantities are found to be interrelated so that one of the quantities can be measured with certainty or with very high accuracy. As a result, the other pairs of physical quantities cannot be measured with certainty. In macroscopic systems or everyday experience, Heisenberg's uncertainty principle seems irrelevant, considering that the accuracy of measuring one quantity will not depend on another quantity. There are several approaches to studying Quantum Mechanics. Two approaches commonly used are the approach based on the method of solving differential equations shaped like the wave equation, called the Schrodinger equation, and another approach based on the method of solving matrix algebra. The existence of these two approaches causes Quantum Mechanics to be sometimes called Wave Mechanics or Matrix Mechanics. By solving the Schrodinger equation, two factors of difficulty are commonly encountered when dealing with specific physics problems: (1). The solution to the Schrodinger equation is generally in the form of a complex function, whereas physical quantities should be actual. Thus, in Quantum Mechanics, which is different from Classical Mechanics, a mathematical mechanism or procedure is needed to produce absolute values based on expressions involving complex functions. (2). The involvement of many independent variables, even in many cases the independent variables are coupled with each other, thus requiring the solution of partial differential equations, not ordinary differential equations. In addition to the difficulty factor in terms of the solution technique above, another difficulty commonly encountered in the process of learning the topic of Quantum Mechanics is the need for a small amount of abstraction to understand a physics problem. This can happen because the phenomena or physics problems being studied are in a realm challenging to imagine, experience, or see directly in everyday experience, namely in the microscopic realm. In contrast, everyday experience or perception is based on the macroscopic realm. In the Quantum Physics I course, a learning approach based on solving differential equations for the Schrodinger Equation and the presentation of matrices based on Dirac's notation has been taken for several models of simple physics problems. As a continuation, Quantum Physics II addresses some of the more complex physics problems and more realistic models. New problems related to the solution					

<table>
<tr><td></td><td colspan="4">method will emerge in coupling between physical quantities, the involvement of many independent variables, and non-standard forms of differential equations. As a result, it is essential to introduce several solving methods, such as operator or algebraic methods and various approximations. To help overcome this difficulty, the process of deepening lecture material is also often added with visual depictions to reduce the difficulty of abstraction in the understanding lecture material. In addition, the learning process of Quantum Physics II is periodically supplemented by giving assignments or homework or assignments to students to improve problem-solving skills and understanding of course material.</td></tr>
<tr><td rowspan="2">Program Learning Outcomes (PLO) Imposed on the Course</td><td>PLO 2</td><td colspan="3">Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.</td></tr>
<tr><td>PLO 5</td><td colspan="3">Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.</td></tr>
<tr><td rowspan="5">Course Outcomes (CO)</td><td colspan="4">After completing this course, students are expected to be able to:</td></tr>
<tr><td>CO1</td><td colspan="3">Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilizing various approaches (approximations).</td></tr>
<tr><td>CO2</td><td colspan="3">Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully.</td></tr>
<tr><td>CO3</td><td colspan="3">Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information.</td></tr>
<tr><td>CO4</td><td colspan="3">Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), to formulate a problem carefully, and try other approaches (approaches) to improve the solution to a challenging problem (challenging problems).</td></tr>
<tr><td rowspan="7">The Correlation of CO to Learning Materials and Methods, and Time Allocation</td><td></td><td>Learning Materials</td><td>Learning Methods</td><td>Time Allocation</td></tr>
<tr><td>CO 1</td><td>An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation</td><td>TCL-SCL mixed</td><td>3X50 minutes</td></tr>
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<tr><td>CO 4</td><td>An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation</td><td>TCL-SCL mixed</td><td>3X50 minutes</td></tr>
<tr><td>CO 2</td><td>Introduction to the concept of orbital and spin angular momentum and the operator properties that represent them, as well as solving eigenvalue problems related to quantum systems</td><td>TCL-SCL mixed</td><td>3X50 minutes</td></tr>
<tr><td>CO 4</td><td>Introduction to the concept of sum or coupling of angular momentum and spin along with the Clebsch-Gordan coefficient</td><td>TCL-SCL mixed</td><td>3X50 minutes</td></tr>
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	CO 3	Some examples of solving physical systems of N-body or identical particles involving angular momentum coupling (L -S and J -J coupling)	TCL-SCL mixed	***3X50 minutes***
	Midterm exam/Project Task Results/Case Analysis Results			
	CO 2	The Introduction of several approach methods (approximations), namely the Variational method	TCL-SCL mixed	***3X50 minutes***
	CO 3	Introduction of several approximations, namely the time-independent Perturbation method	TCL-SCL mixed	***3X50 minutes***
	CO 2	Introduction of several approximations, namely the time-independent Perturbation method	TCL-SCL mixed	***3X50 minutes***
	CO 4	Introduction of several approximation methods, namely the WKB method and its application to the solution of molecular systems	TCL-SCL mixed	***3X50 minutes***
	CO 2	Introduction of the Suzuki -Trotter matrix decomposition method for solving some dynamics problems in quantum systems	TCL-SCL mixed	***3X50 minutes***
	CO 4	The use of the Suzuki - Trotter matrix decomposition method for solving some problems in quantum	TCL-SCL mixed	***3X50 minutes***
	CO 3	Introduction to quantum scattering and Born approximation	TCL-SCL mixed	***3X50 minutes***
	Final exams/ Project Task Results/Case Analysis Results			
Learning Methods	**SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods**			
Student Learning Experience	**Learn to study and study physical systems**			
Access to Learning Media/ LMS and Offline and Online Percentage	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)			

Assessment Methods and Synchronization with CO	**Assessment Methods**	**Assessment Percentage**	**Criteria/ Indicators**	**CO1**	**CO2**	**CO3**	**CO4**
	Participatory Activity*						
	Project Results/ Case Study Results/ PBL Results*						
	Cognitive						

	Assignment	**40**		√		√	
	Midterm Exam	**30**			√		√
	Final Exam	**30**			√		√
	Total	**100**					
	*) can also be obtained from the Midterm or Final Exam as the result of participatory activities or project/ case study results. According to IKU 7, the percentage of project results/ case study/ PBL results is at least 50%.						

References	**Main References;** 1. J. J. Sakurai, J. Napolitano, 2018, Modern Quantum Mechanics, Cambridge University Press, ISBN 9781108499996. 2. Griffiths, D. J., 2018, Introduction to Quantum Mechanics, 3 ed, Cambridge University Press,ISBN-10: 11071896632, ISBN-13: 978-1107189638.
Lecturers (*Team Teaching*)	1. Drs. Pekik Nurwantoro, M.S., Ph.D 2. Dr. M. F. Rosyid

Authorization	**Date of Drafting**	**Lecturer Coordinator**	**Head of Curriculum Committee**	**Head of Study Program**
		Drs. Pekik Nurwantoro, M.S., Ph.D		*Dr. Eng. Ahmad Kusumaatmaja, S.Si., M.Sc.*