SEMESTER LEARNING ACTIVITY PLANS
(SLAP)
SEMESTER ODD 2022/2023

Physics Undergraduate Study Program

Physics Department

Quantum Physics I

MFF 2034/ 3 Credits

Lecturer Coordinator:

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UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
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	Universitas Gadjah Mada Faculty of Mathematics and Natural Science Physics Department / Physics Undergraduate Study Program Semester ODD 2022/2023	**Document Number :** …………

SEMESTER LEARNING ACTIVITY PLANS (SLAP)

Code	Course Name	Credits (Credits)		Semester	Status	Prerequisite
MFF 2034	*Quantum Physics I*	*T: 3*	*P: …*	*ODD*	*Compulsory*	*Mechanics I (MFF1401)*

Short Description	The Quantum Physics I course is an introductory course related to the study of Quantum Mechanics in the 2021 Curriculum for the Undergraduate Physics Study Program, FMIPA UGM. 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 a similar Max Planck review, including those occurring 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 in such a way that if 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 is based on solving differential equations in the form of the Wave equation, called the Schrodinger equation, and another approach based on the Matrices Algebraic solution methode by Heisenberg. The existence of these two approaches causes Quantum Mechanics to be sometimes called Wave Mechanics or Matrix Mechanics. Through solving the Schrodinger equation, two factors of difficulty are commonly encountered when dealing with some physical issues, namely: (1). The solution to the Schrodinger equation is generally in the form of a complex function, whereas physical quantities should be accurate. Thus, in Quantum Mechanics, which is different from Classical Mechanics, a mathematical mechanism or procedure is needed that is able 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 quantity of abstraction to understand a physics problem. This can happen because the phenomena or physical problems 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. Various methods of delivering learning related to Quantum Mechanics are commonly used in various Text Books. This is related to the formulation of Quantum Mechanics, which, formally, Mathematics can be done from various approaches (approach). Several approaches in the

	formulation of Quantum Mechanics include solving differential equations or expressions of linear and matrix algebra, as well as expressions of functional forms. In the eyes In the Quantum Physics I lecture, the learning approach was chosen based on the method that most Quantum Mechanics Textbooks widely adopt, namely, based on solving the differential equation for the Schrodinger Equation, along with its matrix representation. With the form of differential equations, abstract understanding in solving examples of physical phenomena will be minimal, considering that some physical quantities still appear explicitly in the Schrodinger equation that represents them. Thus, the Quantum Physics I course emphasizes that students concentrate more on understanding the physical aspects of each phenomenon in the microscopic world being studied, not only on understanding the mathematical aspects of solving procedures. To fulfill this, several simple models of a physical phenomenon that appear on a microscopic scale will be studied so that students are able to understand various important aspects that distinguish between quantum phenomena and classical phenomena. To assist students in understanding the procedure for solving the Schrodinger equation, the process of deepening course material is also often added with visual depictions to reduce abstraction difficulties in the understanding lecture material. In addition, the learning process of Quantum Physics I is periodically also equipped with the provision of assignments or homework or assignments to students to improve problem-solving skills and understanding of lecture material. Learning is carried out based on a face-to-face schedule in class for 14 weeks, with each week consisting of two meetings of 50 and 100 minutes. Four weeks during the lecture period are used for the Mid-Semester Examination (UTS) and the Final Semester Examination (UAS), each of which is carried out on a scheduled basis for two weeks by the Academic Section of FMIPA UGM. Evaluation for students for course assessment is carried out summatively and formatively. Summatively, this is manifested in the form of written exams, both UTS and UAS, which take a maximum of 120 minutes. The formative evaluation is realized in the form of independent assignments for each student. The form of independent activity is the form of completing an assignment given to students to be discussed in groups and then completed independently at home in the form of a written report for each of these assignments. The monitoring process is carried out by looking at student activities during the lecture process, such as attendance at lectures, questions and answers and discussions on the material being presented, and student performance in carrying out independent assignments in the form of homework given.	
Program Learning Outcomes (PLO) Imposed on the Course	***PLO 2***	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.
	PLO 5	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.
Course Outcomes (CO)	**After completing this course, students are expected to be able to:**	
	CO1	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 utilize various approaches (approximations).
	CO2	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.
	CO3	Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information.
	CO4	Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).

		Learning Materials	Learning Methods	Time Allocation
The Correlation of CO to Learning Materials and Methods, and Time Allocation	***CO 1***	Background and early development of Quantum Mechanics and the potential role of quantum mechanics in the latest technological developments.	TCL-SCL mixed	***3X50 minutes***
	CO 1	Introduction of several new concepts that can explain the experimental results of several physical phenomena regarding aspects of matter and waves	TCL-SCL mixed	***3X50 minutes***
	CO 1	Introduction to the formal aspects of mathematics and the interpretation of several expressions in the formulation of quantum mechanics from the description of differential equations and the correspondence of their matrix expressions through linear algebra.	TCL-SCL mixed	***3X50 minutes***
	CO 4	The introduction of several operators representing physical quantities, the Hermitian property, the probability density of finding a particle, the expected value of a physical quantity, the measurement uncertainty of a physical quantity, and the Heisenberg uncertainty concept. A brief introduction to the postulates of quantum theory.	TCL-SCL mixed	***3X50 minutes***
	CO 2	Infinite well potential system. The description of the one-dimensional bound model for a potential is in the form of a well of infinite depth.	TCL-SCL mixed	***3X50 minutes***
	CO 4	Finite well potential system. An explanation of the one-dimensional model for a potential in the form of a well of finite depth.	TCL-SCL mixed	***3X50 minutes***
	CO 3	Interpretation of quantum mechanical results. An explanation of the solution of a finite linear well potential system.	TCL-SCL mixed	***3X50 minutes***
	Midterm exam/Project Task Results/Case Analysis Results			
	CO 2	The linkage of the potential embankment system with reflection and transmission events. Explanation of the analogy of reflection and transmission events in optics with reflection and breakthrough phenomena of particles in quantum mechanics.	TCL-SCL mixed	***3X50 minutes***

	CO 3	(continued) Introduction and completion of the Harmonic Oscillator system. Explanation of the one-dimensional model for a parabolic potential with the solution of differential equations.	TCL-SCL mixed	***3X50 minutes***
	CO 2	Introduction and completion of Harmonic Oscillator system. Explanation of the one-dimensional model for potential in the form of parabolic with differential equation solution.	TCL-SCL mixed	***3X50 minutes***
	CO 4	Introduction to the algebraic solution of the harmonic oscillator and compare it to the results obtained through differential equations. Explanation of the emergence of energy quantization and quantum breakthrough	TCL-SCL mixed	***3X50 minutes***
	CO 2	Introduction and completion of the Atomic Hydrogen system. Explanation of the three-dimensional model for the Hydrogen Atom Explanation for reducing the reduction from a two-body system to a one-body system.	TCL-SCL mixed	***3X50 minutes***
	CO 4	Details the steps for solving the Schrodinger equation for Hydrogen atoms in the radial variable section. An explanation of the steps needed to simplify the solution of partial differential equations.	TCL-SCL mixed	***3X50 minutes***
	CO 3	Understanding orbital angular momentum and its relation to the completion of the Hydrogen atom in the variable angular section. An explanation of the emergence of orbital angular momentum operators in the Hydrogen atom problem and matters related to the conservation of orbital angular momentum and its quantization.	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 analyze and study physical systems**			

<table>
<tr><td>Access to Learning Media/ LMS and Offline and Online Percentage</td><td colspan="7">Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)</td></tr>
<tr><td rowspan="10">Assessment Methods and Synchronization with CO</td><td>Assessment Methods</td><td>Assessment Percentage</td><td>Criteria/ Indicators</td><td>CO1</td><td>CO2</td><td>CO3</td><td>CO4</td></tr>
<tr><td>Participatory Activity*</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Project Results/ Case Study Results/ PBL Results*</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Cognitive</td></tr>
<tr><td>Assignment</td><td>40</td><td></td><td>√</td><td></td><td>√</td><td></td></tr>
<tr><td>Midterm Exam</td><td>30</td><td></td><td></td><td>√</td><td></td><td>√</td></tr>
<tr><td>Final Exam</td><td>30</td><td></td><td></td><td>√</td><td></td><td>√</td></tr>
<tr><td>Total</td><td>100</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">*) 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%.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>References</td><td colspan="7">Main References;
1. D. J. Griffiths, 2018, Introduction to Quantum Mechanics 3rd Edition, Cambridge University Press, ISBN-10 : 1107189632, ISBN-13 : 978-1107189638.
2. Schwabl, F., 2007, Quantum Mechanics, 4th ed. Springer-Verlag, Berlin.</td></tr>
<tr><td>Lecturers (Team Teaching)</td><td colspan="7">1. Drs. Pekik Nurwantoro, M.S., Ph.D
2. Prof.,Agung Bambang Setio Utomo, S.U., Ph.D</td></tr>
<tr><td rowspan="2">Authorization</td><td>Date of Drafting</td><td colspan="2">Lecturer Coordinator</td><td colspan="2">Head of Curriculum Committee</td><td colspan="2">Head of Study Program</td></tr>
<tr><td></td><td colspan="2">Drs. Pekik Nurwantoro, M.S., Ph.D</td><td colspan="2"></td><td colspan="2">Dr. Eng. Ahmad Kusumaatmaja, S.Si., M.Sc.</td></tr>
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