SEMESTER LEARNING ACTIVITY PLANS (SLAP)

SEMESTER ODD 2022/2023

Physics Undergraduate Study Program

Physics Department

Statistical Physics

MFF 2051/ 3 Credits

Lecturer Coordinator:

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Dr. Harsojo, SU

UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
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<tr><td></td><td>Universitas Gadjah Mada
Faculty of Mathematics and Natural Science
Physics Department / Physics Undergraduate Study Program
Semester ODD 2022/2023</td><td>Document Number :
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<tr><th>Code</th><th>Course Name</th><th colspan="2">Credits (Credits)</th><th>Semester</th><th>Status</th><th>Prerequisite</th></tr>
<tr><td>MFF 2051</td><td>Statistical Physics</td><td>T: 3</td><td>P: …</td><td>ODD</td><td>Compulsory</td><td>Thermodynamics (MFF1053), Quantum Physics I (MFF2034*)</td></tr>
<tr><td>Short Description</td><td colspan="6">The Statistical Physics course is compulsory for the Bachelor of Physics study program at Gadjah Mada University. This course can be taken by students in the odd semester of their third year (semester V) or earlier with the approval of the instructor. Before taking this course, students must have passed the Thermodynamics course (MFF 2053) and Quantum Physics I (MFF 2034). A deep understanding of Statistical Physics is needed for a physics student, especially those who will study applied physics which involves the interaction of many particles found in condensed matter physics and particle and high energy physics.
In contrast to other courses, in the statistical physics course, students will be faced with abstract problems concerning mathematical problems such as permutations and combinations. In other words, statistical physics is a statistical, mathematical problem with physical boundary conditions so that it has a physical interpretation. In statistical physics, the general approach is the average approximation of a particle object without looking at the object individually. As an illustration of the problem of atomic or subatomic gas particles, the number of objects or particles involved is huge (of the order of 1020 particles). Meanwhile, each particle has six degrees of freedom in three spaces and three momentum components. Thus the averaging approach in statistical physics will play an essential role in understanding the macroscopic phenomena of the system under review.
To assist students in understanding statistical physics courses, the main topics that will be discussed in this course include fundamental theories in statistical physics such as the micro and macro states of many-particle systems, the concept of phase space, the density of microstates, the virial theorem and the Gibbs paradox. Furthermore, an introduction to ensemble theory which includes microcanonical, canonical, and microcanonical ensembles, will also be given, including the concept of the partition function, the relationship between entropy and phase space, and the relationship between the partition function and thermodynamic quantities. An introduction to quantum statistics is also given, including the concepts of pure and mixed states and the density operator. The last is an introduction to the types of statistics, including Maxwell-Boltzman, Biose-Einstein, and Fermi Dirac statistics. An introduction to quantum statistics is also given to equip students, starting with the density operator concept. Finally, examples of statistical physics applications will also be given in this lecture.</td></tr>
<tr><td rowspan="2">Program Learning Outcomes (PLO) Imposed on the Course</td><td>PLO 2</td><td colspan="5">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="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.</td></tr>
<tr><td rowspan="3">Course Outcomes (CO)</td><td colspan="6">After completing this course, students are expected to be able to:</td></tr>
<tr><td>CO1</td><td colspan="5">Students can understand and explain the basic concepts of statistical physics.</td></tr>
<tr><td>CO2</td><td colspan="5">Students can apply the basic concepts obtained in some instances.</td></tr>
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	CO3	Students can identify a problem involving statistical physics and be able to solve the problem through the use of the methods and fundamental concepts that have been given previously.		
	CO4	Students are skilled in solving physics cases through theoretical-mathematical or phenomenological approaches.		
	CO5	Students can present, communicate and provide arguments on a concept/idea about statistical physics.		
	CO6	Students can work in solving cases both independently and in groups.		
The Correlation of CO to Learning Materials and Methods, and Time Allocation		**Learning Materials**	**Learning Methods**	**Time Allocation**
	CO 1	a. Basic concepts of statistical physics: Micro and macro states of many particle systems, the concept of phase divisions, equipartition theory, virial theorem, Gibbs' paradox, and examples of problems.,	TCL-SCL mixed	***3X50 minutes***
	CO 1	b. Ensembles in statistical mechanics: Microcanonical and canonical ensembles	TCL-SCL mixed	***3X50 minutes***
	CO 1	b. Ensembles in statistical mechanics: Canonical macro ensembles.	TCL-SCL mixed	***3X50 minutes***
	CO 2	b. Ensemble in statistical mechanics: The concept of the partition function, the relationship between entropy, and the phase space density.	TCL-SCL mixed	***3X50 minutes***
	CO 2	b. Ensembles in statistical mechanics: Observables as ensemble means, Relation of partition functions and thermodynamic quantities.	TCL-SCL mixed	***3X50 minutes***
	CO 2	c. Quantum Statistics: Pure state and mixed state, density operator, 3rd law of thermodynamics.	TCL-SCL mixed	***3X50 minutes***
	CO 3	c. Quantum Statistics: Symmetry of the multi-particle wave function, Explanation of the mid-semester exam (UTS) grid.	TCL-SCL mixed	***3X50 minutes***
	Midterm exam/Project Task Results/Case Analysis Results			
	CO 3	d. Types of statistics: Maxwell-Boltzmann	TCL-SCL mixed	***3X50 minutes***
	CO 4	d. Types of statistics: Bose-Einstein	TCL-SCL mixed	***3X50 minutes***
	CO 4	d. Statistical types: Fermi-Dirac	TCL-SCL mixed	***3X50 minutes***
	CO 5	e. Applications of Statistical Physics: Plank Radiation	TCL-SCL mixed	***3X50 minutes***
	CO 5	e. Applications of Statistical Physics: Condensation of Bosons	TCL-SCL mixed	***3X50 minutes***
	CO 6	e. Applications of Statistical Physics: Fermi Gases	TCL-SCL mixed	***3X50 minutes***

	CO 6	e. Applications of Statistical Physics: Landau Diamagnetics and Pauli Paramagnetic	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	**(1) Read teaching materials before lectures, (2) Download teaching materials before lectures,**			
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	CO5	CO6
Participatory Activity*								
Project Results/ Case Study Results/ PBL Results*								
Cognitive								
Homework	**20**		√	√	√	√	√	√
Midterm Exam	**40**		√	√	√			
Final Exam	**40**				√	√	√	√
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. Greiner W. Dkk., 1997, Thermodynamic and statistical mechanics, Springer, New York.. 2. Sears, F. W. dan G. L. Salinger, 1982, Thermodynamics, kinetic theory, and statistical thermodynamics, Addison-Wesley, Reading, Massachussetts.
Lecturers (*Team Teaching*)	1. Dr. Moh. Adhib Ulil Absor, M.Sc. 2. Dr. Harsojo, SU

Authorization

Date of Drafting	Lecturer Coordinator	Head of Curriculum Committee	Head of Study Program
	Dr. Moh. Adhib Ulil Absor, M.Sc.		*Dr. Eng. Ahmad Kusumaatmaja, S.Si., M.Sc.*