UNESA	**Universitas Negeri Surabaya** **Faculty of Mathematics and Natural Sciences** **Physics Education Undergraduate Study Program**	**Document Code**

SEMESTER LEARNING PLAN

Courses	CODE	Course Family	Credit Weight			SEMESTER	Compilation Date
Statistical Physics	8420302247		T=2	P=0	ECTS=3.18	6	July 17, 2024

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	Dr. Z.A. Imam Supardi, M.Si.	....	Mita Anggaryani, M.Pd., Ph.D.

Learning model: Case Studies

Program Learning Outcomes (PLO)

PLO study program which is charged to the course

Program Objectives (PO)

PO - 1	Master the theoretical concepts of Statistical Physics in general and the theoretical concepts of Classical Statistical distribution (Maxwell-Boltzmann) and Quantum Statistical distribution (Bose-Einstein and Fermi-Dirac) in depth;
PO - 2	Able to formulate procedural problem solving related to the application of distribution theoretical concepts of Classical Statistics and Quantum Statistics to several microscopic physical system phenomena.
PO - 3	Demonstrate an attitude of faith, intelligence, independence, honesty, caring, resilience in solving problems related to the application of distribution theoretical concepts of Classical Statistics and Quantum Statistics to several microscopic physical system phenomena.

PLO-PO Matrix

P.O
PO-1
PO-2
PO-3

PO Matrix at the end of each learning stage (Sub-PO)

P.O	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PO-1																
PO-2																
PO-3																

Short Course Description

Statistical Physics studies the behavior of microscopic systems with a very large number of forming particles through two approaches, namely classical statistical distribution laws (Maxwell-Boltzmann statistics) and quantum statistical distribution (Bose-Einstein statistics and Fermi-Dirac statistics). In the lecture, the differences between the three statistical distribution laws will be explained and the application of the three types of distribution to several physics cases, for example ideal gases and true gases, boson gases and fermion gases, classical and semi-classical gases, Gibbs paradox, classical and semi-classical gas entropy. -classical, monatomic and diatomic gases, specific heat of monatomic and diatomic gases, specific heat of solids according to classical and quantum statistics, and the total partition function in the presence of molecular interactions, as well as the introduction of ensemble concepts (micro canonical, canonical, and large canonical).

References

Main :

1. Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.
2. Pointon, A. J. 1978. An Introduction to Statistical Physics. London, UK: Longmann.
3. Beiser, A. 1988. Perspective of Modern Physics. London, UK: McGraw-Hill.
4. Serway, R. A. et al. 2005. Modern Physics. California, US: Thomson Learning Inc.
5. Kittel, C. and H. Kroemer. 1980. Thermal Physics. New York, US: W. H. Freeman and Co.
6. Tipler, P. A. 1990. Physics for Scientists and Engineers. New York, US: W. H. Freeman and Co.

Supporters:

Supporting lecturer	Dr. Zainul Arifin Imam Supardi, M.Si. Dr. Rohim Aminullah Firdaus, S.Pd, M.Si Utama Alan Deta, S.Pd., M.Pd., M.Si. Dr. Fitriana, S.Si. Dr. Muhimmatul Khoiro, S. Si.

Week-	Final abilities of each learning stage (Sub-PO)	Evaluation		Help Learning, Learning methods, Student Assignments, [Estimated time]		Learning materials [References]	Assessment Weight (%)
		Indicator	Criteria & Form	Offline (*offline*)	Online (*online*)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Understand the differences between macro and micro systems, as well as the physical laws that govern these two physical systems	Students are able to understand the differences between macro and micro physical systems as well as the relevant physical laws that govern these two physical systems	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** General Overview, Statistical Distribution Functions, Phase Space, Bibliography Scope **:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
2	Understand the basic principles of the classical Maxwell-Boltzmann statistical distribution to derive several physical quantity distribution functions	Students are able to understand the basic principles of classical Maxwell-Boltzmann statistics and solve problems related to distribution functions	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Speed Distribution Function, Momentum Distribution Function, Energy Distribution Function **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
3	Understand the basic principles of classical Maxwell-Boltzmann statistics and their application to several physical cases related to microscopic systems	Students are able to understand the basic principles of classical Maxwell-Boltzmann statistics and solve problems related to the application of classical Maxwell-Boltzmann statistics	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Application of Maxwell-Boltzmann Statistics, Equipartition Theory based on a review of Maxwell-Boltzmann Classical Statistics, Specific Heat of Ideal Gases **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
4	Understand the application of classical Maxwell-Boltzmann statistics to several physical cases related to microscopic systems and the classical Boltzmann partition function	Students are able to solve problems calculating the specific heat of monatomic gases and formulating equations of state and kinetic energy of ideal gases	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lectures, Discussions, Questions and Answers, Assignments 2 x 50 minutes	Lectures, Discussions, Questions and Answers, Assignments 2 x 50 minutes	**Material:** Equipartition Theory based on a review of Maxwell-Boltzmann Classical Statistics, Specific Heat of an Ideal Gas, Boltzmann Partition Function **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%

5	Understand the basic principles of the Bose-Einstein quantum statistical distribution and its application to several physical cases related to microscopic systems	Students are able to understand the basic principles of Bose-Estein quantum statistics and solve problems related to boson systems	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Boson Systems, Boson Populations, Bose-Einstein Gas **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
6	Understand the basic principles of the Bose-Einstein quantum statistical distribution and its application to several physical cases related to microscopic systems in black body heat radiation	Students are able to understand the basic principles of Bose-Estein quantum statistics and solve problems related to Planck's theory of black body radiation	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Application of Bose-Einstein Quantum Statistics, Black Body Radiation, Concept of Photons as Bosons, Quantum Theory of Planck Radiation **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
7	Understand the basic principles of the Bose-Einstein quantum statistical distribution and its application to several physical cases related to microscopic systems in solids	Students are able to solve problems calculating the specific heat of solids according to the classical approach, Einstein and Debye's atomic vibrations	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	**Material:** Application of Bose-Einstein Quantum Statistics, Specific Heat of Solids, Concept of Phonons as Bosons, Einstein's Theory, Debye's Theory **Library:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
8	Students are able to master the theoretical concepts of classical statistical distribution or Maxwell-Boltzmann statistics	Students are able to understand and solve USS questions that are relevant to classical statistical distribution teaching material well and correctly	**Criteria:** Quantitative	Written Test 2 x 50 minutes	Written Test 2 x 50 minutes	**Material:** Mid-semester Evaluation **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	10%
9	Understand the basic principles of Fermi-Dirac quantum statistics and their application to several physical cases related to microscopic systems	Students are able to understand the basic principles of Fermi-Dirac quantum statistics and solve problems related to fermion systems	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Fermion System, Fermion Population, Fermi-Dirac Gas **Reference:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%

10	Understand the basic principles of Fermi-Dirac quantum statistics and their application to several physical cases of heat propagation in metals	Students are able to understand the basic principles of Fermi-Dirac quantum statistics and solve problems related to the existence of conduction electrons in metals	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Application of Fermi-Dirac Quantum Statistics, Conduction Electron Theory, Fermi Theory Conduction Electrons as Fermions **Library:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
11	Understand the basic principles of Fermi-Dirac quantum statistics and their application to several physical cases of heat propagation in metals	Students are able to solve problems related to heat propagation in metals and calculating the specific heat of metals according to the theory of conduction electrons in Fermi seas	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	**Material:** Application of Fermi-Dirac Quantum Statistics, Conduction Electron Theory, Conduction Electrons as Fermions, Fermi Theory, Specific Heat of Metals **Library:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
12	Understand the basic principles of gas thermodynamics according to classical and quantum statistics, the concept of entropy for closed systems and open systems	Students are able to understand the basic principles of gas thermodynamics according to classical and quantum statistics and solve problems related to system entropy	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Gas Thermodynamics according to Classical and Quantum Statistics, Entropy Concept, Open and Closed Systems, Entropy Concept, Entropy Change, Classical Gases, Gibbs Paradox, Semi-Classical Gases **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
13	Understand the basic principles of gas thermodynamics according to classical and quantum statistics, entropy changes, classical gases, Gibbs paradox, and semi-classical gases	Students are able to solve problems related to entropy changes in semi-classical gas systems, and can prove the equation of state and total energy of an ideal gas	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	Lecture, Discussion, Question and answer, Assignment 2 x 50 minutes	**Material:** Diatomic Gas, Quantum Model of Rotational Motion, Quantum Model of Vibrational Motion, Total Partition Function of Diatomic Gas **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%

14	Understand the basic principles of the quantum model of diatomic gases, the combination of translational motion, rotation and vibration of molecules, the total partition function for diatomic gases	Students are able to solve problems related to quantum models of rotational and vibrational motion of diatomic gas molecules and the total partition function of diatomic gases	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Diatomic Gas, Quantum Model of Rotational Motion, Quantum Model of Vibrational Motion, Total Partition Function of Diatomic Gas, Specific Heat of Diatomic Gas **Reference:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
15	Understanding ensemble models to describe microscopic systems, the role of the total partition function in the Helmholtz energy formula to derive the equation of state and the total energy of gases with/without the presence of molecular interactions	Students are able to understand the importance of ensemble modeling to describe microscopic systems and can derive total partition function formulations for classical and semi-classical gases as well as partition function formulations in the presence of molecular interactions	**Criteria:** Qualitative **Form of Assessment** : Participatory Activities	Lecture, Discussion, Question and answer 2 x 50 minutes	Lecture, Discussion, Question and answer 2 x 50 minutes	**Material:** Canonical Ensemble, Total Partition Function of Classical Systems, Total Partition Function of Semi-Classical Systems, Total Partition Function in the presence of molecular interactions **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	5%
16	Final Semester Evaluation / Final Semester Examination	1. Students are able to understand the basic principles of Fermi-Dirac quantum statistics and solve problems related to fermion systems 2. Students are able to understand the basic principles of Fermi-Dirac quantum statistics and solve problems related to the existence of conduction electrons in metals 3. Students are able to solve problems related to heat propagation in metals and calculating the specific heat of metals according to the theory of conduction electrons in Fermi seas 4. Students are able to understand the basic principles of gas thermodynamics according to classical and	**Criteria:** Quantitative	Written Test 2 x 50 minutes	Written Test 2 x 50 minutes	**Material:** Final Semester Evaluation **References:** *Prastowo, T. 2014. Lecture Notes on Statistical Physics. Unpublished work.*	20%

		quantum statistics and solve problems related to system entropy 5. Students are able to solve problems related to quantum models of rotational and vibrational motion of diatomic gas molecules and the total partition function of diatomic gases 6. Students are able to solve problems related to the total partition function of diatomic gases, the equation of state and total kinetic energy of diatomic gases, and reduce the specific heat of diatomic gases. 7. Students are able to understand the importance of ensemble modeling to describe microscopic systems and can derive total partition function formulations for classical and semi-classical gases as well as partition function formulations in the presence of molecular interactions					

Evaluation Percentage Recap: Case Study

No	Evaluation	Percentage
1.	Participatory Activities	70%
		70%

Notes

1. **Learning Outcomes of Study Program Graduates (PLO - Study Program)** are the abilities possessed by each Study Program graduate which are the internalization of attitudes, mastery of knowledge and skills according to the level of their study program obtained through the learning process.
2. **The PLO imposed on courses** are several learning outcomes of study program graduates (CPL-Study Program) which are used for the formation/development of a course consisting of aspects of attitude, general skills, special skills and knowledge.
3. **Program Objectives (PO)** are abilities that are specifically described from the PLO assigned to a course, and are specific to the study material or learning materials for that course.
4. **Subject Sub-PO (Sub-PO)** is a capability that is specifically described from the PO that can be measured or observed and is the final ability that is planned at each learning stage, and is specific to the learning material of the course.
5. **Indicators for assessing** abilities in the process and student learning outcomes are specific and measurable statements that identify the abilities or performance of student learning outcomes accompanied by evidence.
6. **Assessment Criteria** are benchmarks used as a measure or measure of learning achievement in assessments based on predetermined indicators. Assessment criteria are guidelines for assessors so that assessments are consistent and unbiased. Criteria can be quantitative or qualitative.
7. **Forms of assessment:** test and non-test.
8. **Forms of learning:** Lecture, Response, Tutorial, Seminar or equivalent, Practicum, Studio Practice, Workshop Practice, Field Practice, Research, Community Service and/or other equivalent forms of learning.
9. **Learning Methods:** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other equivalent methods.

10. **Learning materials** are details or descriptions of study materials which can be presented in the form of several main points and sub-topics.
11. **The assessment weight** is the percentage of assessment of each sub-PO achievement whose size is proportional to the level of difficulty of achieving that sub-PO, and the total is 100%.
12. TM=Face to face, PT=Structured assignments, BM=Independent study.