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
STATISTICAL PHYSICS		PHYSICS	T= 3 units	P=?	5 (five)	5 December 2020

AUTHORISATION	AUTHOR	COURSE COORDINATOR	HEAD OF PHYSICS STUDY PROGRAM
PHYSICS DEPARTMENT	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 Statistical Physics in general and Classical Statistics (Maxwell-Boltzmann distribution) and Quantum Statistics (Bose-Einstein and Fermi-Dirac distributions) comprehensively.
	CLO-3	Being able to formulate problem solving for procedural problems relevant to the applications of both Classical and Quantum Statistics to some statistical phenomena found in microscopic systems.
	Final competence in each step of learning (Sub-CLO)	
	Sub-CLO1	Being able to understand differences between microscopic and macroscopic systems as well as laws of physics control the two.
	Sub-CLO2	Being able to understand basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases.
	Sub-CLO3	Being able to understand basic principles of Bose-Einstein Statistics and its applications to black-body radiation.
	Sub-CLO4	Being able to understand basic principles of Bose-Einstein Statistics and its applications to the specific heat of solids.
	Sub-CLO5	Being able to understand basic principles of Fermi-Dirac Statistics and its applications to conduction electrons on metals.
	Sub-CLO6	Being able to understand basic principles of Fermi-Dirac Statistics and its applications to the specific heat of metals.

	Sub-CLO7	Being able to understand basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy for open and closed systems.
	Sub-CLO8	Being able to understand basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy and a change in entropy of a system, classical gases, Gibbs paradox, semi-classical gases.
	Sub-CLO9	Being able to understand basic principles of quantum model of diatomic gases, a combined motion of molecular translation, rotation and vibration, total partition function for diatomic gases.
	Sub-CLO10	Being able to understand ensemble model for description of microscopic systems, the role of total partition function in formulation of Helmholtz energy to derive the equation of state and total energy of gases with or without the presence of molecular interaction.
Course Description	Statistical Physics examines the behaviour of microscopic systems having extremely huge number of constituting particles through an approach of both classical distribution of Maxwell-Boltzmann Statistics and quantum distribution of Bose-Einstein and Fermi-Dirac Statistics. During class discussion, differences among the three statistical distribution are explained. The applications of the classical and quantum statistical distribution are discusssed that include ideal and real gases, boson and fermion gases, classical and semi-classical gases, Gibbs paradox, entropy of classical and semi-classical gases, monoatomic and diatomic gases, the specific heat of monoatomic and diatomic gases, the specific heat of solids based on classical and quantum calculations, and total partition function in the presence of molecular interaction, and the introduction of concepts of micro canonical, canonical and grand canonical ensembles.	
Topic Discussions: Learning Materials	1. General consideration: statistical distribution function, phase space, scopes of Statistical Physics 2. Velocity, momentum and kinetic energy distribution functions, the applications of Maxwell-Boltzmann Statistics, equipartition principle and the specific heat of gases, Boltzmann partition function 3. Boson system and its population, Bose-Einstein gas, the applications of Bose-Einstein Statistics, thermal radiation of the black-body, photon as boson, Planks' radiation law 4. Boson system and its population, Bose-Einstein gas, the applications of Bose-Einstein Statistics, calculations of the specific heat of solids, phonon as boson, Einstein theory, Debye theory 5. Fermion system and its population, Fermi-Dirac gas, the applications of Fermi-Dirac Statistics, conduction electrons as fermion, Fermi theory 6. Fermion system and its population, Fermi-Dirac gas, the applications of Fermi-Dirac Statistics, calculations of the specific heat of metals 7. Thermodynamics of gases based on classical and quantum statistical distributions, concepts of entropy, open and closed systems 8. Concepts of entropy, a change in entropy, classical and semi-classical gases, Gibbs paradox 9. Diatomic gases, quantum model of translational, rotational and vibrational motions, total partition function for diatomic gases 10. Ensembles of micro canonical, canonical, grand canonical systems, total partition functions of classical and semi-classical systems, total partition function in the presence of molecular interaction	
References	**Primary:**	
	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.
	Secondary:
	Some power point files and/or course materials relevant to Statistical 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 differences between microscopic and macroscopic systems as well as laws of physics control the two systems	Students can explain differences between microscopic and macroscopic systems as well as laws of physics control the two systems			Contextual Learning Class discussion Q & A	• General consideration • Statistical distribution function • Phase space • Scopes of Statistical Physics	
2	Being able to understand basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases	Students can explain basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and			Contextual Learning Class discussion Q & A	• Velocity, momentum and kinetic energy distribution functions • The applications of Maxwell-Boltzmann Statistics • Equipartition	

		its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases				principle • The specific heat of gases	
3	Being able to understand basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases	Students can explain basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases			Contextual Learning Class discussion Q & A	• Velocity, momentum and kinetic energy distribution functions • The applications of Maxwell-Boltzmann Statistics • Equipartition principle • The specific heat of gases	
4	Being able to understand basic principles of Maxwell-Boltzmann Statistics to derive some physical distribution function and its applications to the structure of an ideal gas in general, equipartition	Students can explain basic principles of Maxwell-Boltzmann Statistics to derive some physical	Exercise on Chap. 2, Lecture Notes on Satistical Physics (Assignment 1)		Contextual Learning Class discussion Q & A	• The applications of Maxwell-Boltzmann Statistics • Equipartition principle • The specific heat of gases	**10%**

	principle and the specific heat of gases	distribution function and its applications to the structure of an ideal gas in general, equipartition principle and the specific heat of gases, solve problems relevant to Maxwell-Boltzmann Statistics				• Boltzmann partition function	
5	Being able to understand basic principles of Bose-Einstein Statistics and its applications to black-body radiation	Students can explain basic principles of Bose-Einstein Statistics and its applications to black-body radiation			Contextual Learning Class discussion Q & A	• Boson system and its population • Bose-Einstein gas • The applications of Bose-Einstein Statistics • Thermal radiation of the black-body • Photon as boson • Planks' radiation law	
6	Being able to understand basic principles of Bose-Einstein Statistics and its applications to the specific heat of solids	Students can explain basic principles of Bose-Einstein Statistics and its applications to the specific heat of solids			Contextual Learning Class discussion Q & A	• Boson system and its populatioN • Bose-Einstein gas • The applications of Bose-Einstein Statistics • Calculations of the specific heat of	

						solids • phonon as boson • Einstein theory • Debye theory	
7	Being able to understand basic principles of Bose-Einstein Statistics and its applications to the specific heat of solids	Students can explain basic principles of Bose-Einstein Statistics and its applications to the specific heat of solids, solve problems relevant to Bose-Einstein Statistics	Exercise on Chap. 3, Lecture Notes on Statistical Physics (Assignment 2)		Contextual Learning Class discussion Q & A	• Boson system and its population • Bose-Einstein gas • The applications of Bose-Einstein Statistics • Calculations of the specific heat of solids • phonon as boson • Einstein theory • Debye theory	**10%**
8	**Mid Semester Exam**						**30%**
9	Being able to understand basic principles of Fermi-Dirac Statistics and its applications to conduction electrons on metals	Students can explain basic principles of Fermi-Dirac Statistics and its applications to conduction electrons on metals			Contextual Learning Class discussion Q & A	• Fermion system and its population • Fermi-Dirac gas • The applications of Fermi-Dirac Statistics • Conduction electrons as fermion • Fermi theory	
10	Being able to understand basic principles of Fermi-Dirac Statistics and its applications to the specific heat of metals	Students can explain basic principles of Fermi-Dirac Statistics and its applications to the specific heat	Exercise on Chap. 4, Lecture Notes on Statistical Physics (Assignment 3)		Contextual Learning Class discussion Q & A	• Fermion system and its population • Fermi-Dirac gas • The applications of Fermi-Dirac Statistics • Calculations of the	**10%**

		of metals, solve problems relevant to Fermi-Dirac Statistics				specific heat of metals	
11	Being able to understand basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy for open and closed system	Students can basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy for open and closed system			Contextual Learning Class discussion Q & A	• Thermodynamics of gases based on classical and quantum statistical distributions • Concepts of entropy • Open and closed systems	
12	Being able to understand basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy for open and closed system	Students can basic principles of thermodynamics of gases based on classical and quantum statistics, concepts of entropy for open and closed system			Contextual Learning Class discussion Q & A	• Thermodynamics of gases based on classical and quantum statistical distributions • Concepts of entropy • Open and closed systems	
13	Being able to understand basic principles of thermodynamics of gases based on classical and quantum statistics, concepts	basic principles of thermodynamics of gases based on classical and			Contextual Learning Class discussion Q & A	• Concepts of entropy • A change in entropy • Classical and semi-	

	of entropy and a change in entropy of a system, classical gases, Gibbs paradox, semi-classical gases	quantum statistics, concepts of entropy and a change in entropy of a system, classical gases, Gibbs paradox, semi-classical gases				classical gases • Gibbs paradox	
14	Being able to understand basic principles of quantum model of diatomic gases, a combined motion of molecular translation, rotation and vibration, total partition function for diatomic gases	Students can explain basic principles of quantum model of diatomic gases, a combined motion of molecular translation, rotation and vibration, total partition function for diatomic gases			Contextual Learning Class discussion Q & A	• Diatomic gases • Quantum model of translational, rotational and vibrational motions • Total partition function for diatomic gases	
15	Being able to understand ensemble model for description of microscopic systems, the role of total partition function in formulation of Helmholtz energy to derive the equation of state and total energy of gases with or	Students can explain ensemble model for description of microscopic systems, the role of total partition			Contextual Learning Class discussion Q & A	• Ensembles of micro canonical, canonical, grand canonical systems • Total partition functions of classical and semi-classical systems • Total partition	

	without the presence of molecular interaction	function in formulation of Helmholtz energy to derive the equation of state and total energy of gases with or without the presence of molecular interaction				function in the presence of molecular interaction	
16	**Final Exam**						**40%**