	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
Thermodynamics	8420303218	Compulsory Study Program Subjects	T=3	P=0	ECTS=4.77	3	July 17, 2024

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	.....	Dr. Frida Ulfah Ermawati, M.Sc.	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	Mastering knowledge of thermodynamic concepts and processes, as well as equations of state
	PO - 2	Formulate thermodynamic systems in the form of the 0th, 1st and 2nd Law Equations of Thermodynamics with the help of mathematics, Entropy of thermodynamic systems
	PO - 3	Design and carry out thermodynamics practical activities with the topics: (1) Adiabatic gas law, (2) Ideal gas, (3) Thermal Expansion, and (4) Heat engine
	PO - 4	Communicate the results of practicum activities and case study results in verbal and written form
	PO - 5	Analyzing the concepts of Enthalpy, Gibbs Function, and Helmholtz Function, and the 2nd Law of Thermodynamics Equation, as well as conducting case studies of several phenomena/events in everyday life which are applications of these concepts. Completing several types of case studies, including analyzing damage to rice-cooker, refrigerator and air conditioning (AC) systems, as well as potential environmental damage due to exploitation of the use of freon in refrigerator systems
	PLO-PO Matrix	

P.O
PO-1
PO-2
PO-3
PO-4
PO-5

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																
PO-4																
PO-5																

Short Course Description	This Thermodynamics MK discusses the basic concepts (macroscopic and microscopic) of thermodynamics, thermal balance, 0th law equations of thermodynamics, equations of state, thermodynamic processes (quasi-static, reversible and irreversible, and cyclical), 1st law equations Thermodynamics, the relationship between internal energy, heat and work in ideal gas systems, isolated systems, closed systems and open systems, and their applications in everyday life. Isothermal, isochoric, isobaric and adiabatic processes. Heat engines, Carnot cycle in ideal gas systems, Entropy of thermodynamic systems, Enthalpy, Gibbs function, and Helmholtz Function, 2nd Law of Thermodynamics Equation, and their application in everyday life in the form of case studies, such as: (1) Engine working principles steamboat, (2) the release of certain gases in the reaction between the vinegar solution and baking powder so that it can inflate balloons, (3) the working principle of rice cookers, and (4) the working principle of refrigerators and air conditioners, as well as (5) analyzing potential damage environment due to exploitation of the use of freon in refrigerator systems. Accompanied by 2 practical activities from the following 4 selected topics: (1) Adiabatic gas law, (2) Ideal gas, (3) Thermal Expansion, and (4) Heat engine.	
References	**Main :**	

	1. Mark W. Zemansky and Richard H. Dittman. 1982. Heat andThermodynamics, Sixth Edition, McGraw- Hill,Inc. Diterjemahkan kedalamBahasa Indonesia oleh The Houw Liong. 1986. Kalor dan termodinamika, terbitan ke enam, Bandung, Institut Teknologi Bandung (ITB). 2. Yunus A. Cengel and Michael Boles. 1994.Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill,Inc
	Supporters:
	1. Darmawan B. 1990. Termodinamika. Jurusan Fisika FMIPA-ITB 2. Yunus A.Cengel and Michael Boles.1994.Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill,Inc
Supporting lecturer	Dra. Suliyanah, M.Si. Dr. Frida Ulfah Ermawati, M.Sc. Setyo Admoko, S.Pd., M.Pd. Lydia Rohmawati, S.Si., M.Si. Muhammad Habibbulloh, M.Pd.

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		Students are able to explain macroscopic and microscopic thermodynamic concepts well	**Form of Assessment** : Participatory Activities	Lecture, Discussion, Problem solving 3 X 50	Share teaching materials & information	**Material:** Explaining the Macroscopic and Microscopic Views Scope of Thermodynamics **Library:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	2%
2		Students are able to present the application of mathematics to solve thermodynamic problems.	**Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Discussion, Question and Answer and Assignment 3 X 50	Share assignment materials	**Material:** Studying equations of state **References:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	3%

3		Students are able to identify the properties of pure substances, pure substance phases, pure substance phase change process, pure substance phase change process diagram, PVT surface diagram.	**Form of Assessment** : Participatory Activities, Tests	Discussion, Presentation and Question and Answer 3 X 50	Share information		2%
4		Students are able to present the concept of temperature and the zeroth law of thermodynamics	**Form of Assessment** : Participatory Activities, Tests	Discussion, Presentation and Question and Answer 3 X 50	-		2%
5			**Form of Assessment** : Participatory Activities, Tests	Discussion and Questions and Answers 3 X 50	Share material/information	**Material:** • Work in Path-Dependent Hydrostatic Systems • Calculating ∫ p dV for Quasistatic Processes • Work in Changes in Wire Length, Changes in Film Surface Area, Charge Transfer in Electrochemical Cells, Total Polarization Changes in Dielectric Solids, Total Magnetization Changes in Paramagnetic Solids • Work General **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	2%

6	Able to think effectively in solving thermodynamic problems	Students are able to differentiate between external businesses; inner effort; quasistatic processes; effort in volume changes; chemical systems; PV diagrams; effort depends on trajectory; work calculations for quasistatic processes; attempts to change the length of the wire; an attempt to change the reverse cell charge.	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers4. Task 3 X 50		**Material:** • Work and Heat • Adiabatic Work • Internal Energy Function • Mathematical Formulation of the First Law of Thermodynamics **References:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%
7	Able to think effectively in solving problems	Students are able to analyze Heat and the First Law of Thermodynamics	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers4. Task 3 X 50		**Material:** • The Concept of Heat • Differential Forms of the First Law of Thermodynamics • Heat Capacity and Its Measurement • Specific Heat of Water: Calories • Hydrostatic System Equations • Quasistatic Flow of Heat; Heat Reservoir • Conduction Heat • Thermal Conductivity **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	3%

8	Able to think effectively in solving thermodynamic problems	Students are able to analyze the concept of heat; adiabatic work; internal energy function; first law of thermodynamics; specific heat; and the heat flow rate is quasistatic.	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers 3 X 50		**Material:** Midterm Exam **Reader:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	20%
9	Able to think effectively in solving thermodynamic problems.	Students are able to analyze thermodynamics; volume control; steady flow process; and unsteady flow processes.	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers4. Task 3 X 50		**Material:** • Equation of State for an Ideal Gas • Internal Energy of a Real Gas • Ideal Gas • Experiments to Determine Heat Capacity • Quasistatic Adiabatic Processes **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%

10	Able to work together effectively in solving thermodynamic problems	Students are able to complete essay assignments about ideal gases	**Criteria:** Full marks will be given to students if all questions are answered correctly **Form of Assessment** : Participatory Activities, Practice/Performance	1. Lecture2. Discussion3. Questions and answers4. Task 3 X 50		**Material:** • Measurement of γ by Ruchhardt Method • Longitudinal Wave Speed • Microscopic View • Kinetic Theory of Ideal Gases **References:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	10%
11	Able to process information effectively in solving thermodynamic problems	Students are able to analyze the second law of thermodynamics	**Criteria:** Full marks will be given to students if all questions are answered correctly. **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers 3 X 50		**Material:** • Conversion of Work into Heat and Vice Versa • Gasoline Engines, Diesel Engines, Steam Engines, Stirling Engines • Heat Engines; Kelvin-Planck Statement of the Second Law of Thermodynamics **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%

12	Able to think effectively in solving thermodynamic problems	Students are able to draw the Carnot cycle and the processes that accompany it	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers 3 X 50		**Materials:** • Refrigerator; Clausius Statement of the Second Law of Thermodynamics • Equivalence of Kelvin-Planck and Clausius Statements • Reversibility and Irreversibility • External and Internal Mechanical Irreversibility • External and Internal Thermal Irreversibility • Chemical Irreversibility • Some States of Reversibility **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%
13	Able to think effectively in solving thermodynamic problems	Students are able to draw the Otto cycle and the processes that accompany it	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practice/Performance, Tests	1. Lecture2. Discussion3. Questions and answers4. Task 3 X 50		**Material:** • Carnot Cycle • Several Examples of the Carnot Cycle • Carnot Refrigerator • Carnot and Collorary Theorems • Thermodynamic Regulated Scales • Absolute Zero and Carnot Efficiency **Bibliography:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%

14	Able to process information effectively in solving thermodynamic problems	Students are able to explain the concept of entropy	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical / Performance, Tests	1. Lecture2. Discussion3. Questions and answers 3 X 50		**Material:** • Absolute Zero and Carnot Efficiency • Ideal Gas Quality and Thermodynamic Temperature **References:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%
15	Able to think effectively in solving thermodynamic problems	Students are able to formulate Maxwell's equations; general relationship for dU; dS; dH dG; dF; CV; and Cp; H; S; U various gases.	**Criteria:** Full marks will be given to students if all questions are answered correctly **Forms of Assessment** : Participatory Activities, Practical Assessment, Practical / Performance, Tests	1. Lecture2. Discussion3. Questions and answers 3 X 50		**Material:** • Entropy • Caratheodory Principle • Tdeal Gas Entropy • TS Diagram • Entropy and Reversibility • Entropy and Irreversibility • Heat and Entropy in Reversible Processes • Entropy and Conditions of Disequilibrium **Library:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	5%

16			**Forms of Assessment** : Participatory Activities, Practice/Performance, Tests			**Material:** Final Semester Exam **Reader:** *Mark W. Zemansky and Richard H. Dittman. 1982. Heat and Thermodynamics, Sixth Edition, McGraw-Hill, Inc. Translated into Indonesian by The Houw Liong. 1986. Heat and thermodynamics, sixth edition, Bandung, Bandung Institute of Technology (ITB). 2. Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	20%

Evaluation Percentage Recap: Case Study

No	Evaluation	Percentage
1.	Participatory Activities	36.69%
2.	Project Results Assessment / Product Assessment	1.5%
3.	Portfolio Assessment	1.25%
4.	Practical Assessment	1.25%
5.	Practice / Performance	30.19%
6.	Test	28.19%
		99.07%

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** ability in the process and student learning outcomes are specific and measurable statements that identify the ability 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.