UNESA	**Universitas Negeri Surabaya** **Faculty of Mathematics and Natural Sciences** **Undergraduate Physics Study Program**	**Docume**

SEMESTER LEARNING PLAN

Courses	CODE	Course Family	Credit Weight			SEMESTER	Compila Date
Thermodynamics	4520103212	Compulsory Study Program Subjects	T=3	P=0	ECTS=4.77	3	August 2

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	Tim Pengajar	Dr. Frida Ulfah Ermawati, M.Sc.	Prof. Dr. Munasir, S.Si., M

Learning model: Case Studies

Program Learning Outcomes (PLO)

PLO study program which is charged to the course

PLO-9	Able to work as an individual or team effectively, have entrepreneurial skills, and care about environmental issues.
PLO-11	Design and conduct experiments in physics learning by applying scientific methods

Program Objectives (PO)

PO - 1	Students are able to master knowledge about the concepts and processes of the laws of thermodynamics and equations of state
PO - 2	Students are able to analyze and formulate thermodynamic systems in the form of the 1st and 2nd Thermodynamic Equations with the help of mathematics, Entropy of thermodynamic systems
PO - 3	Students are able to 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	Students are able to communicate the results of practicum activities and case study results in verbal and written form
PO - 5	Students are able to complete the case studies given well, both individually and in teams, analyzing the working concepts that occur in thermodynamic systems in everyday life

PLO-PO Matrix

P.O	PLO-9	PLO-11
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 Course discusses the basic concepts (macroscopic and microscopic) of thermodynamics, thermal balance, 0th law of thermodynamics, equation of state, thermodynamic processes (qua reversible and irreversible, and cyclical), 1st law of thermodynamics equation. , The relationship between internal energy, heat and work in ideal gas systems, isolated systems, closed systems and open systems, a their applications in everyday life. Isothermal, isochoric, isobaric and adiabatic processes. Carnot cycle in an ideal gas system, Entropy of a thermodynamic system, Enthalpy, Gibbs function, and Helmholtz function, I of the 2nd Law of Thermodynamics, and its application in everyday life, in the form of case studies, such as: (1) The working principle of a steamboat engine , (2) the release of a certain gas in the reaction betv vinegar solution and baking powder so that it can inflate the balloon, (3) the working principle of a rice cooker, and (4) the working principle of a refrigerator and air conditioner. Accompanied by 2 practical activities 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 ke enam, Bandung, Institut Teknologi Bandung (ITB).
2. F W Sears and G L Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics. Addison Wesley. ISBN-13: 978-0201068948. (for explanations and problems)
3. Yunus A. Çengel and Michael A. Boles ,2015,,Thermodynamics: An Engineering Approach, 8th edition,ISSN: 978-981-4595-29-2

Supporters:

1. Darmawan B. 1990. Termodinamika. Jurusan Fisika FMIPA-ITB
2. https://byjus.com/physics/thermodynamics/
3. https://www.livescience.com/50776-thermodynamics.html
4. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Thermodynamics/The_Four_Laws_of_Thermod
5. http://hyperphysics.phy-astr.gsu.edu/hbase/heacon.html

Supporting lecturer

Dr. Frida Ulfah Ermawati, M.Sc.
Setyo Admoko, S.Pd., M.Pd.
Lydia Rohmawati, S.Si., M.Si.
Dr. Eng. Evi Suaebah, M.Si., M.Sc.
Dr. Fitriana, S.Si.

Week-	Final abilities of each learning stage (Sub-PO)	Evaluation		Help Learning, Learning methods, Student Assignments, [Estimated time]		Learning materials [References]	Asse Wei
		Indicator	Criteria & Form	Offline (*offline*)	Online (*online*)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	

1	1. Provides critical analysis of thermodynamic concepts and processes, as well as equations of state 2. Have an attitude and sense of responsibility towards the environment by applying the concepts of thermodynamics in order to preserve the environment.	1. Able to explain macroscopic and microscopic concepts of thermodynamics well 2. Able to understand thermal balance and the 0th Law of Thermodynamics Equation 3. Able and have an attitude and sense of responsibility towards the environment by applying the concepts of thermodynamics in order to preserve the environment.	**Criteria:** non-test **Form of Assessment** : Participatory Activities	• Learning Form: Offline • Learning Method: Lecture, discussion, Question and answer. 3 x 50 minutes		**Material:** Temperature and the Zeroth 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).* **Material:** Temperature and the Zeroth Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB* **Material:** • Temperature Concept • Thermometers and Temperature Measurement • Comparison of Several Thermometers • Ideal Gas Temperature • Several Thermometer Scales **Library:** *http://hyperphysics.phy-astr.gsu.edu/...*	
2	1. Provides critical analysis of thermodynamic concepts and processes, as well as equations of state 2. Have an attitude and sense of responsibility towards the environment by applying the concepts of thermodynamics in order to preserve the environment.	1. Able to explain macroscopic and microscopic concepts of thermodynamics well 2. Able to understand thermal balance and the 0th Law of Thermodynamics Equation 3. Have an attitude and sense of responsibility towards the environment by applying the concepts of thermodynamics in order to preserve the environment.	**Criteria:** non-test **Form of Assessment** : Participatory Activities	• Learning Form: Offline • Learning Method: Lecture, discussion, Question and answer. 3 x 50 minutes		**Material:** Temperature and the Zeroth 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).* **Material:** Temperature and the Zeroth Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB* **Material:** • Temperature Concept • Thermometers and Temperature Measurement • Comparison of Several Thermometers • Ideal Gas Temperature • Several Thermometer Scales **Library:** *http://hyperphysics.phy-astr.gsu.edu/...*	
3	1. Analyzing processes in thermodynamics, the 1st Law of Thermodynamics and its application in everyday life 2. Mastering thermodynamic processes (quasi static, reversible and irreversible, and cyclical 3. Mastering the relationship between internal energy, heat and work in ideal gas systems, isolated systems, closed systems and open systems 4. Have an attitude and sense of responsibility towards the environment by applying the concepts of thermodynamics in order to preserve the environment.	1. Explaining Thermodynamic Equilibrium 2. Explaining the Equation of State 3. Explain the Hydrostatic System 4. Explaining Mathematical Theorems 5. Explaining Stretched Wire 6. Explaining Thin Membrane Surfaces 7. Explain Electrochemical Cells 8. Explaining Dielectric Layers 9. Explaining Paramagnetic Rods 10. Explaining Intensive and Extensive Coordinates	**Criteria:** non-test **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Presentation, discussion and question and answer. • Student Assignments: Giving individual and/or group assignments of 3 x 50 minutes		**Material:** Several Simple Thermodynamic Systems **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).* **Material:** Several Simple Thermodynamic Systems **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	

4	Analyzing processes in thermodynamics, the 1st Law of Thermodynamics and its application in everyday life	1. Explaining Thermodynamic Equilibrium 2. Explaining the Equation of State 3. Explain the Hydrostatic System 4. Explaining Mathematical Theorems 5. Explaining Stretched Wire 6. Explaining Thin Membrane Surfaces 7. Explain Electrochemical Cells 8. Explaining Dielectric Layers 9. Explaining Paramagnetic Rods 10. Explaining Intensive and Extensive Coordinates	**Criteria:** non-test **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Presentation, discussion and question and answer. • Student Assignments: Giving individual and/or group assignments of 3 x 50 minutes		**Material:** Several Simple Thermodynamic Systems **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).* **Material:** Several Simple Thermodynamic Systems **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
5	Analyzing processes in thermodynamics, the 1st Law of Thermodynamics and its application in everyday life	1. Calculating ∫ p dV for Quasistatic Processes 2. Explain the work of changing wire length, changing film surface area, charge transfer in electrochemical cells, changing total polarization in dielectric solids, changing total magnetization in paramagnetic solids. 3. Explaining Work in General 4. Explain Alloy Systems	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** work **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).* **Material:** work **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
6	Distinguishing important processes in thermodynamics in ideal gases through PV diagrams, as well as discussing Heat engines, Carnot cycles	1. Explain Work and Heat 2. Explaining Adiabatic Work 3. Explaining the Function of Internal Energy 4. Explain the Mathematical Formulation of the First Law of Thermodynamics 5. Explain the concept of heat 6. Explaining the Differential Form of the First Law of Thermodynamics 7. Explaining Heat Capacity and Its Measurement 8. Explaining Specific Heat of Water: Calories	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Heat and 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).* **Material:** Heat and the First Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
7	Distinguishing important processes in thermodynamics in ideal gases through PV diagrams, as well as discussing Heat engines, Carnot cycles	1. Explaining the Hydrostatic System Equations 2. Explain the Quasistatic Flow of Heat 3. Explaining Heat Reservoirs 4. Explain Conduction Heat 5. Explain Thermal Conductivity and Its Measurement 6. Explain Convection Heat 7. Explaining Thermal Radiation; Black Thing 8. Explain Kirchhoff's Laws; Radiation Heat 9. Explaining Stefan-Boltzmann's Law	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Heat and 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).* **Material:** Heat and the First Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	

8	1. UTS 2. Able to solve questions related to meetings 1 to 7	1. Students can explain the zeroth law of thermodynamics, the 1st law of thermodynamics, quasi-static processes, adiabatic processes, isobars, and isothermal 2. Students can analyze and calculate the value of work in a cycle 3. Students can analyze and calculate the expansion and compressibility of water	**Criteria:** Quantitative **Form of Assessment** : Test	Written Test 2 x 100 minutes		**Material:** Temperature and the Zeroth Law of Thermodynamics; Some Simple Thermodynamic Systems; Work; Some Simple Thermodynamic Systems **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).* **Material:** Temperature and the Zeroth Law of Thermodynamics; Some Simple Thermodynamic Systems; Work; Some Simple Thermodynamic Systems **Bibliography:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB* **Material:** Temperature and the Zeroth Law of Thermodynamics; Some Simple Thermodynamic Systems; Work; Some Simple Thermodynamic Systems **Bibliography:** *Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	
9	After attending a thermodynamics lecture on ideal gas material, students can state the characteristics of an ideal gas with mathematical equations, with a minimum 80% correct assessment at the end of the lecture.	1. Explain the Equation of State for an Ideal Gas 2. Explaining the Internal Energy of Real Gases 3. Explaining Ideal Gases 4. Explaining Experiments to Determine Heat Capacity 5. Explaining Quasistatic Adiabatic Processes	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Ideal Gas **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).* **Material:** Ideal Gas **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
10	After attending a thermodynamics lecture on ideal gas material, students can state the characteristics of an ideal gas with mathematical equations, with a minimum 80% correct assessment at the end of the lecture.	1. Explaining γ Measurements Using the Ruchhardt Method 2. Explaining Longitudinal Wave Speed 3. Explaining Microscopic View 4. Explaining the Kinetic Theory of Ideal Gases	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Ideal Gas **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).* **Material:** Ideal Gas **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
11	After following the work conversion material from various machines in thermodynamics, students can design practical activities with assessments in the form of quizzes/practicum reports with a success rate of 80	1. Explain the conversion of work into heat and vice versa 2. Explaining Gasoline Engines, Diesel Engines, Steam Engines, Stirling Engines 3. Explaining Heat Engines; Kelvin-Planck Statement of the Second Law of Thermodynamics 4. Explaining Refrigerators; Clausius Statement of the Second Law of Thermodynamics 5. Explaining the Equivalence of the Kelvin-Planck and Clausius Statements	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Second 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).* **Material:** Second Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	

12	After following the work conversion material from various machines in thermodynamics, students can design practical activities with assessments in the form of quizzes/practicum reports with a success rate of 80	1. Explaining Reversibility and Irreversibility 2. Explaining External and Internal Mechanical Irreversibility 3. Explaining External and Internal Thermal Irreversibility 4. Explaining Chemical Irreversibility 5. Explaining Some Inverse States	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Second 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).* **Material:** Second Law of Thermodynamics **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
13	Third semester students majoring in physics will be able to design and carry out practical work on the Carnot cycle and the thermodynamic temperature scale correctly, after following the presentation of thermodynamics lecture material with an observation level of 80% correct	1. Explaining the Carnot Cycle 2. Explaining several examples of the Carnot cycle 3. Explain Carnot Refrigerator 4. Explaining Carnot's and Collorary's Theorems	**Form of Assessment** : Participatory Activities, Tests	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Carnot Cycle and Thermodynamic Temperature Scale **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).* **Material:** Carnot Cycle and Thermodynamic Temperature Scale **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
14	Third semester students majoring in physics will be able to design and carry out practical work on the Carnot cycle and the thermodynamic temperature scale correctly, after following the presentation of thermodynamics lecture material with an observation level of 80% correct	1. Explain the Thermodynamic Temperature Scale 2. Explaining Absolute Zero and Carnot Efficiency 3. Explaining Ideal Gas Qualities and Thermodynamic Temperature	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Carnot Cycle and Thermodynamic Temperature Scale **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).* **Material:** Carnot Cycle and Thermodynamic Temperature Scale **Reference:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	
15	After studying entropy material, students can formulate and formulate mathematical equations for the thermodynamic entropy system, with a minimum assessment quiz score of 80% correct	1. Explaining Entropy 2. Explaining Caratheodory's Principle 3. Explaining Tdeal Gas Entropy 4. Explaining TS Diagrams 5. Explaining Entropy and Reversibility 6. Explain Entropy and Irreversibility 7. Explaining Heat and Entropy in Reversible Processes 8. Explaining Entropy and Conditions of Disequilibrium 9. Explain the Principle of Increase in Entropy 10. Explain the Application of the Entropy Principle 11. Explaining Entropy and Disorder 12. Explaining Exact Differentials	**Form of Assessment** : Participatory Activities, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, case method, and presentation • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Entropy **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).* **Material:** Entropy **Reader:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB*	

16	Students are able to solve questions related to material from the 9th to 15th meetings	1. Students can analyze and calculate questions about quasistatic adiabatics 2. Students can analyze and calculate the heat of an adiabatic process 3. Students can analyze and calculate machine efficiency 4. Students can analyze questions about entropy	**Criteria:** Quantitative	UAS 2 x 50 minutes		**Material:** Ideal Gas; Second Law of Thermodynamics; Carnot Cycle and Thermodynamic Temperature Scale; Library Entropy **:** *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).* **Material:** Ideal Gas; Second Law of Thermodynamics; Carnot Cycle and Thermodynamic Temperature Scale; Entropy **Library:** *Darmawan B. 1990. Thermodynamics. Department of Physics, FMIPA-ITB* **Material:** Ideal Gas; Second Law of Thermodynamics; Carnot Cycle and Thermodynamic Temperature Scale; Entropy **Library:** *Yunus A. Cengel and Michael Boles. 1994. Thermodynamics An Engineering Approach, Second Edition, McGraw-Hill, Inc*	

Evaluation Percentage Recap: Case Study

No	Evaluation	Percentage
1.	Participatory Activities	102.5%
2.	Portfolio Assessment	5%
3.	Practical Assessment	57.5%
4.	Test	30%
		100%

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.