Thermodynamics

Course description sheet

Basic information

Field of study Mechanical Engineering **Major** - **Organisational unit** Faculty of Mechanical Engineering and Robotics **Study level** First-cycle (engineer) programme **Form of study** Full-time studies **Profile** General academic	**Didactic cycle** 2023/2024 **Course code** RMBMENS.li4.04302.23 **Lecture languages** English **Mandatoriness** Obligatory **Block** General Modules **Course related to scientific research** Yes

Course coordinator	Paweł Madejski
Lecturer	Paweł Madejski, Tomasz Kuś, Jakub Szymiczek

Period Semester 3	**Method of verification of the learning outcomes** Exam **Activities and hours** Lectures: 28 Auditorium classes: 26 Laboratory classes: 14	**Number of ECTS credits** 6

Goals

C1	Provide students with knowledge of the basic laws and principles of thermodynamics.
C2	Introduce students to methods and techniques for solving tasks and problems in technical thermodynamics, and to methods and techniques for determining the basic parameters of the state in an analyzed thermodynamic system.
C3	Make the audience aware of the importance of thermodynamic processes in the operation of machines and devices and in the natural environment.

Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
Knowledge – Student knows and understands:			
W1	Student has elementary knowledge of technical thermodynamics as a mechanical and material engineering discipline.	MBMEN1A_W02, MBMEN1A_W03, MBMEN1A_W07, MBMEN1A_W10, MBMEN1A_W17	Participation in a discussion, Execution of laboratory classes, Test, Examination, Report on completion of a practical placement
W2	Student knows the basic methods and techniques used in solving problems in technical thermodynamics	MBMEN1A_W02, MBMEN1A_W03, MBMEN1A_W07, MBMEN1A_W09, MBMEN1A_W17	Participation in a discussion, Execution of laboratory classes, Test, Examination, Report on completion of a practical placement
Skills – Student can:			
U1	Student is able to identify the basic states and state parameters and create a mathematical model of a thermodynamic system.	MBMEN1A_U01, MBMEN1A_U02, MBMEN1A_U03, MBMEN1A_U07, MBMEN1A_U09, MBMEN1A_U11, MBMEN1A_U16	Activity during classes, Participation in a discussion, Execution of exercises, Test, Examination
U2	Student is able to use thermodynamics to describe physical phenomena and mathematical modeling of heat, mass, and combustion exchange in technological processes	MBMEN1A_U01, MBMEN1A_U03, MBMEN1A_U07, MBMEN1A_U08, MBMEN1A_U09	Activity during classes, Participation in a discussion, Execution of exercises, Test, Examination
U3	Student is able to choose the instruments and measurement methods and to measure the basic parameters of the thermodynamic system, develop and draw conclusions from the obtained results.	MBMEN1A_U01, MBMEN1A_U02, MBMEN1A_U07, MBMEN1A_U08, MBMEN1A_U09, MBMEN1A_U11, MBMEN1A_U14, MBMEN1A_U16	Activity during classes, Participation in a discussion, Execution of exercises, Test, Examination
Social competences – Student is ready to:			

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
K1	Student is aware of the impact of thermodynamic processes on the social and natural environment.	MBMEN1A_K01, MBMEN1A_K02, MBMEN1A_K04, MBMEN1A_K05	Execution of laboratory classes, Test, Examination, Report on completion of a practical placement, Completion of laboratory classes

Program content ensuring the achievement of the learning outcomes prescribed to the module

Student learns the basic concepts and classifies thermodynamic systems. Student knows the parameters of the state, he can identify them and determine their values. Student learns the principles of thermodynamics and their use to describe technical problems, can applie the Equation of State to describe the properties of gases. Student knows the basic transformations of an ideal gas, and can define the thermodynamic efficiency of the cycles, as well as the methods of measuring basic thermodynamic parameters.

Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	28
Auditorium classes	26
Laboratory classes	14
Preparation for classes	38
Realization of independently performed tasks	57
Examination or final test/colloquium	2
Preparation of project, presentation, essay, report	10
Student workload	**Hours** 175
Workload involving teacher	**Hours** 68

* hour means 45 minutes

Program content

No.	Program content	Course's learning outcomes	Activities
1.	1. Thermodynamic system, intensive and extensive state parameters, Zero Law of Thermodynamics, physical quantities of basic state parameters, relative and absolute scales 2. Energy and its types, internal energy, the principle of energy conservation, energy transfer mechanisms, the concepts of heat and work and their relationship with energy, the basics of balancing 3. The First Law of Thermodynamics for a closed and open system, enthalpy, work and energy conversion processes, examples of closed and open systems (nozzles, diffusers, turbines, compressors, valves, chambers, pipes, channels, heat exchangers), efficiency of energy conversion processes 4. Thermodynamic substances, division and types of substances, phase transitions. Gas equation of state, perfect and semi-perfect gas. Specific heat of perfect and semi-perfect gases, heat capacity 5. Equations of state of real gas, gas mixtures, mass, molar and volume fractions 6. Thermodynamic processes, characteristic processes for perfect and semi-perfect gases, reversible and irreversible 7. Thermodynamic cycles, the Second Law of Thermodynamics, entropy, the reversible Carnot cycle, engine and refrigeration cycles 8. Heat engines, refrigerators and heat pumps, cycle energy efficiency, examples of thermodynamic cycles in technology, exergy analysis 9. Wet gases: humid air characteristics, i-X (Mollier) diagram and humid air processes 10. Processes of water vapor, introduction to vapor powers systems and gas power systems	W1, W2, U1, U3, K1	Lectures

No.	Program content	Course's learning outcomes	Activities
2.	1. Thermodynamic system, determination intensive and extensive state parameters and their units, normal conditions 2. Balancing of thermodynamic systems, the principle of conservation of mass and energy of a thermodynamic system, heat and work 3. The First Law of Thermodynamics, system balancing, internal energy, enthalpy 4. Equation of state of an ideal gas, equation of state of real gas, specific heat of ideal gases 5. Specific heat of semi-perfect gases, real gas, gas mixtures 6. Characteristic gas processes 7. The Second Law of Thermodynamics: entropy, the principle of increasing entropy. Reversible Carnot cycle 8. Thermodynamic cycles, engines, refrigerators, heat pumps, efficiency and effectiveness of the thermodynamic cycle, exergy analysis 9. Wet gases: humid air characteristics, i-X (Mollier) diagram and humid air processes 10. Saturated and superheated steam: processes of water vapor	W1, W2, U1, U2, K1	Auditorium classes
3.	0. Introduction to experimental thermodynamics. OSH training 1. Temperature measurement. Instruments and methods of temperature measurement 2. Pressure measurement. Instruments and methods of pressure measurement 3. Balancing of thermodynamic systems according to the first law of thermodynamics 4. Analysis of basic thermodynamic processes 5. Heat pump cycle 6. Processes of humid air 7. Completion of laboratory exercises	W2, U1, U3, K1	Laboratory classes

Extended information/Additional elements

Teaching methods and techniques :

Practice method (doing tasks at the blackboard), Group work, Demonstration, Discussion, Lectures

Activities	Methods of verification	Credit conditions
Lectures	Test, Examination	
Audit. classes	Activity during classes, Participation in a discussion, Execution of exercises, Test, Examination	
Lab. classes	Execution of laboratory classes, Test, Examination, Report on completion of a practical placement, Completion of laboratory classes	

Conditions and the manner of completing each form of classes, including the rules of making retakes, as well as the conditions for admission to the exam

Audit. classes passed on the basis of colloquium grades. The amount of credit is the average of the grades from all tests, it may include grades for active participation in classes. During the semester, the way of improving failed tests and the number of attempts is determined by the teacher. The basic deadline for obtaining a credit is the end of classes in the semester. The student has the right to one make-up date in the main part of the session in order to obtain a credit. Absence from the colloquium should be excused at the first class after the colloquium. In the absence of an excuse, the absence is treated as a failing grade. In the absence of a credit in the basic term, unsatisfactory grades (2.0) are also taken into account when calculating the final grade in the make-up dates. Laboratory exercises are credited on the basis of credits from individual exercises. In order to pass the exercise, it is necessary to correctly prepare the results of the measurements of the report) and pass the theoretical foundations. The amount of credit is the average of the grades from individual exercises. All laboratory exercises must be completed and the method of making up for absences is determined by the person conducting the given exercise. Absence should be excused at the first class after its occurrence. The basic deadline for obtaining a credit is the end of classes in the semester. The student has the right to one make-up date in the main part of the session in order to obtain a credit. In the absence of credit in the basic term, failing grades (2.0) are taken into account when calculating the amount of credit in the make-up dates. The condition for admission to the exam is a pass (positive grade) in the auditorium and laboratory exercises.

Method of determining the final grade

Final grade = 0.6 exam grade + 0.2 lab grade + 0.2 auditorium grade. When determining the final grade, unsatisfactory grades (2.0) from all failed exam dates are taken into account.

Manner and mode of making up for the backlog caused by a student justified absence from classes

Audit. classes: Absence from the colloquium should be excused during the first class after the colloquium. In the absence of an excuse, the absence is treated as a failing grade.
Lab. classes: All exercises must be completed. Classes should be carried out with another group after agreeing with the instructor. If there is no such possibility, the exercise should be made up in an additional time or on the terms agreed with the instructor. Making up missed classes must be completed before the end of classes in the semester.

Prerequisites and additional requirements

Completed course in mathematics and physics; basic knowledge of chemistry

Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lecture: Students participate in classes learning the next content of teaching in accordance with the syllabus of the subject. Students should ask questions and clarify doubts on an ongoing basis. Audiovisual recording of the lecture requires the consent of the lecturer.
Audit. classes: When starting the exercises, students are required to prepare themselves in the scope indicated each time by the teacher (e.g. in the form of sets of tasks). The assessment of the student's work may be based on oral or written statements in the form of a test, which, in accordance with the AGH University of Science and Technology regulations, translates into the final grade for this form of classes.
Lab. classes: Students perform laboratory exercises in accordance with the materials provided by the teacher. The student is

obliged to prepare himself in the subject of the exercise, which can be verified in an oral or written test. Assessment of the course takes place on the basis of presenting the solution to the given problem. Passing the module is possible after passing all laboratory classes

Literature

Obligatory

1. Moran M.J., Shapiro H.N., Boettner D.D., Bailey M.B., Fundamentals of engineering thermodynamics, 8 ed., Wiley 2014
2. Cengel Y., Boles M., Kanoglu M., Thermodynamics – Am Engineering Approach, 9th edition, McGraw-Hill, USA, 2019
3. Szewczyk W., Lectures in Engineering Thermodynamics. Selected Problems. AGH University of Science and Technology Press, Kraków 2009.
4. Luscombe J. H.: Thermodynamics CRS Press London 2018
5. Chich Wu, Thermodynamics and Heat Powered Cycles, A Cognitive Engineering Approach, Nova Science Publisher, New York, USA 2007

Optional

1. Pauken M., Thermodynamics for dummies, Wiley, 2011

Scientific research and publications

Publications

1. Madejski P., Ertesvåg I.S., Ziółkowski P., Mikielewicz D., Energy and exergy analysis of negative CO2 emission gas power plant operation using thermodynamic modelling results of the cycle. Conference Proceedings: 2nd International Conference on Negative CO2 Emissions, June 14-17, 2022, Göteborg, Sweden.
2. Madejski P., Żymełka P., Calculation methods of steam boiler operation factors under varying operating conditions with the use of computational thermodynamic modeling, Energy 2020, Vol. 197, s. 1-12
3. Ziółkowski P., Madejski P., Amiri M., Kuś T., Stasiak K., Subramanian N., Pawlak-Kruczek H., Badur J., Niedzwiecki Ł., Mikielewicz D., Thermodynamic analysis of negative CO2 emission power plant using Aspen Plus, Aspen Hysys and Ebsilon Software, Energies 2021, 14(19), 6304.
4. Madejski P., Subramanian N., Peta S., Thermodynamic analysis of the concept of solar-coal hybrid power plant. Conference Proceedings: Young Scientists in Power Engineering, 5–7 July 2021, Wrocław, Poland.

Learning outcomes prescribed to a field of study

Code	Content
MBMEN1A_K01	A student is prepared for creative activity in the field of designing the production and operation of machines and production systems as well as managing, developing production and management in design, construction and technological enterprises and related industries, research institutes and research and development centres
MBMEN1A_K02	A student has a need for continuous training and improvement of professional and personal competences
MBMEN1A_K04	A student knows the general principles of creating and developing forms of individual entrepreneurship, using knowledge from the studied discipline, can think and act in an entrepreneurial manner
MBMEN1A_K05	A student makes efforts to convey information about the role of technology and the threats resulting from it and opinions in an understandable way using the mass media
MBMEN1A_U01	A student has the ability to use advanced knowledge in the field of fundamental sciences useful for the design, manufacture and operation of machines and production systems
MBMEN1A_U02	A student has the ability to use advanced knowledge in the field of mechanics, design, manufacture and operation of machines and production systems
MBMEN1A_U03	A student has the knowledge to model and calculate complex mechanical systems using numerical methods
MBMEN1A_U07	A student has management skills, including quality management, and knows the basic principles of running a business
MBMEN1A_U08	A student knows how to present their own ideas using modern multimedia techniques
MBMEN1A_U09	A student can use internet technologies efficiently
MBMEN1A_U11	A student can analyze, interpret data, and prepare raports, including knowing the elementary principles of signal analysis
MBMEN1A_U14	A student is able to evaluate the usefulness and the possibility of using new achievements (techniques and technologies) in the studied engineering discipline
MBMEN1A_U16	A student can critically analyse the functioning and evaluate devices, objects, systems, processes, services, etc
MBMEN1A_W02	A student has knowledge of engineering software
MBMEN1A_W03	A student knows optimization methods
MBMEN1A_W07	A student knows how to shape machine elements based on strength criteria
MBMEN1A_W09	A student has knowledge of modern engineering materials, shaping their structure and properties, rules for the selection of engineering materials for application as elements of machines and tools
MBMEN1A_W10	A student knows Computer Aided Materials Design (CAMD) and Computer Aided Materials Selection (CAMS)
MBMEN1A_W17	A student has specialist knowledge of designing, manufacturing and operating selected machines, mechanical devices, technological processes and manufacturing systems