POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Thermodynamics [S1MiBM2>Term]

Course

Field of study
Mechanical Engineering

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Student shoud have knowledge of mathematics and physics, should be able to obtain needed information (from the Internet and library), should be ready to work in team.

Course objective

The purpose of the course is to acquaint student with the basic laws of thermodynamics and their practical application. The aim of the course is also to draw attention to the issues of ecology

Course-related learning outcomes

Knowledge:
1. The student has basic knowledge of thermodynamics, including the knowledge necessary to understand the basic physical phenomena occurring in engineering practice.
2. The student knows the basic principles of thermodynamics, has knowledge of thermal cycles, thermal effects of chemical reactions and heat transport.
3. The student is aware of the impact of thermodynamic processes on the natural environment.

Skills:

1. The student is able to obtain information from the literature, is able to integrate the obtained information, interpret it, as well as draw conclusions and formulate and justify opinions in the field of technical thermodynamics.
2. The student is able to work individually and in a team in the field of thermodynamics, is able to estimate the time needed to complete the assigned task, and is able to develop and implement a work schedule that ensures meeting deadlines.

Social competences:
1. The student understands the need and knows the possibilities of continuous education in the field of thermodynamics, is also ready to critically evaluate the knowledge acquired, recognizes its importance in solving cognitive and practical problems.
2. The student understands the non-technical aspects and effects of an engineer's activity in the field of thermodynamics, including the impact on the environment and the related responsibility for decisions made, is ready to fulfill social obligations, co-organize activities for the benefit of the social environment and initiate activities in the public interest.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Knowledge acquainted during the lecture is verified by a 90-minute written exam and a short oral exam. The written exam consist of 15 questions - the pass threshold is 50% of all scores student can get. A list of 30 questions is sent to students by e-mail 2-weeks in advance. Knowledge acquainted during tutorial classes is verified by the final test.The final laboratory grade is the arithmetic mean of the grades from individual laboratory exercises.

Programme content

Lecture:
Basic definitions and units. Perfect gas equation and van der Waals equation. Definition of work. The status functions. The first law of thermodynamics (the closed and opened system). The specific heat. The second law of thermodynamics - spontaneous processes, irreversibility of processes, dissipation heat. The ideal gas / real gas. Mixture of perfect gases. Analysis of thermodynamic processes: isothermal process, isochoric process, isobaric process, reversible process, polytropic 3 process. The efficiency of compression and expansion processes. The right-hand and left-hand cycle. Thermal efficiency of the circuits (Carnot, Brayton-Joule). Free energy and free enthalpy. The third law of thermodynamics - Nernst theorem. Heat of combustion. The Kirchhoffa i Hessa laws. Chemical affinity. Maxwell's thermodynamic equations. Phase transitions. Water-vapor diagram. Supercritical fluids. The basic processes of humid air and drying process. Heat transfer. Conduction through the membranes without and with an internal heat source. The exemplary solutions of thermal conductivity equation. The natural and forced convection. Radiation - basic concepts of radiation, Stefan Boltzmann's law, radiation heat exchangers. Tutorial classes: solving practical problems.
Exercises
The theoretical part discussed during the lecture will be implemented while solving the tasks. The solved tasks include issues related to several topics of the lecture. Exercises will be performed in the field of energy balance, thermodynamic transformations, thermodynamic cycles, systems without heat exchange and with heat exchange.
Laboratory
The following activities will be carried out during practical laboratory classes:
Measurement of air humidity.
Energy balance. The first law of thermodynamics.
Study of a shell and tube heat exchanger.
Energy balance of a compressor heat pump.
Efficiency of a condensing boiler.
Determination of heat transfer coefficient for solid materials, brass, aluminium, stainless steel, plastics.

Course topics

Lecture and tutorial class
1. Basic thermodynamic parameters and their units. Open system and closed system. The equation of state of an ideal gas and the van der Waals equation. Definition of work, heat of dissipation. Spontaneous

processes. The first and second laws of thermodynamics. The state functions: internal energy, enthalpy, entropy. Specific heat at constant volume and constant pressure. The isentropic exponent. Computational examples (tutorial classes).
2. The first and second laws of thermodynamics: computational examples for an open system. Dalton's law – ideal gas mixtures, constitutive equations. Basic thermodynamic processes: isobar, isochore, isotherm, and isentrope. The isentropic equation. Computational examples (tutorial classes).
3. Thermodynamic cycles: cycle equation, cycle efficiency. The Carnot cycle and the Brayton-Joule cycle. Regeneration. Isentropic efficiency of compression and expansion processes. Computational examples (tutorial classes).
4. Phase transitions. Water-vapor diagram. Critical point. Thermodynamics of humid air. Computational examples (tutorial classes).
5. Free enthalpy, free energy. Energy effects of chemical reactions, Hess's law and Kirchhoff's law. Enthalpy of formation. The third law of thermodynamics. Computational examples (tutorial classes).
6. Heat transfer methods: conduction, convection, and radiation. Fourier's law. Solving the thermal conductivity equation: conduction without and with an internal heat source. Examples: heat flow through a multilayer flat plate and through a cylinder with a circular cross-section. Newton's law, heat transfer coefficient. Computational examples (tutorial classes).
7. The forced convection and free convection. The convective heat transfer along a horizontal and vertical flat plate. Laminar/turbulent flow. Similarity theory. Similarity numbers: Reynolds, Prandtl, Nusselt, Grashof. Empirical equations for determining the heat transfer coefficient. Computational examples (tutorial classes).
8. Radiation. Stefan-Boltzmann equation. Black-body, white-body, and gray-body models. Wien's law. The radiative heat transfer between two parallel planes perpendicular to the ground. Complex heat transfer. Radiation of gases. Computational examples (tutorial classes).

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Teaching methods

The lecture is conducted using a multimedia presentation (illustrated with examples on the board).
Tutorial classes: solving of an engineering problems on the board.
Laboratories performed at the measurement station.

Bibliography

Basic:
1. Szargut, J. Termodynamika, PWN, Warszawa, 2000.
2. Wiśniewski, S., Wiśniewski, T., Wymiana ciepła, WNT, 2002.
3. Furmański, P., Domański, R., Wymiana ciepła, Przykłady obliczeń i zadania, Oficyna Wydawnicza Politechniki Warszawskiej, 2002.

Additional:
1.Cengel, Y., Boles, M.A., Thermodynamics, an engineering approach, Mc Graw Hill, 2008
2.Incropera, F., DeWitt, D., Fundamentals of heat and mass transfer, Wiley, 2008
3.Ghiaasiaan, M., Convective heat and mass transfer, Cambridge University Press, 2014

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00