Course name: ***Thermodynamics***

ECTS	6.0
Course status	*facultative*
Course final assessment /evaluation of outcomes	*Exam / graded credit*
Prerequisite	*Basics of physics*

Main field of study: ***Environmental Engineering***

Educational profile	*General academic*
Code of studies and education level	*bachelor*
Semester of studies	*winter or summer*
Language of instruction	*English*

Course offered by:

Name of faculty offering the course	*Environmental Engineering and Land Surveying*
Name of department offering the course	*Department of Rural Building*
Course coordinator	*Jan Radoń, Ph.D., Agnieszka Sadłowska, Ph.D.*

Learning outcomes:

Symbol of outcome	Description of the learning outcome	Reference to main field of study outcomes	Area symbol*
KNOWLEDGE – student knows and understands:			
THD_K1	*zero, first and second law of thermodynamics and its applications in environmental engineering; physical processes affecting external and internal climate.*	*IS1_W02 IS1_W08*	*T*
SKILLS – student is able to:			
THD_S1	*use thermodynamic properties such as temperature, pressure, internal energy, enthalpy, entropy etc.; create engineering applications of thermodynamics in heating, air conditioning etc.*	*IS1_U03 IS1_U04*	*T*
SOCIAL COMPETENCIES – student is ready to:			
THD_C1	*critically assess his knowledge, continuous self-education and improve his competences*	*IS1_K01*	*T*

Teaching contents

Lectures:	15 hours
Topics	1. *Introduction to thermodynamic concepts and nomenclature. System (closed system) and Control Volume (open system); Characteristics of system boundary and control surface. Thermodynamic state. Zeroth law of thermodynamics.* 2. *Basic gas laws (Boyle's, Charls, Gay Lussac).* 3. *Volume and the number of molecules: Avogadro's law. Ideal gas equation of state (P-V-T relation).* 4. *Total air conditioning applications (psychrometrics). Mollier chart* 5. *First Law of Thermodynamics. Energy, internal energy as a property, components of energy, thermodynamic distinction between energy and work; concept of enthalpy,*

	definitions of specific heat at constant volume and at constant pressure. 6. *Identifications of directions of occurrences of natural processes. Entropy. Second law of thermodynamics.* 7. *Expressions for displacement work in various processes through p-v, p-s diagrams. Schematic representation, efficiency and coefficient of performance. Carnot cycle.* 8. *Heat transfer; Conduction, Convection, Radiation. Fourier's law. Heat transfer trough multilayer building assembly.*
Accomplished learning outcomes	*THD_K1, THD_C1*
Means of verification, rules and criteria of assessment	*Single-choice test, positive assessment should be given at least 50% of correct answers to given questions: <50% – insufficient (2.0); 50–60% – sufficient (3.0); 61–70% – satisfactory plus (3,5); 71–80% – good (4.0); 81–90% – good plus (4,5); 91–100% – very good (5.0). The share of the lecture grade in the final grade is 50%.*
Seminars:	30 hours
Topics	1. *Basic thermodynamics' definitions. Units and conversions.* 2. *Applying thermodynamic properties using Boyle's, Charls and Gay Lussac's law.* 3. *Calculations of gas parameters using equations of state for an ideal gas. Representation of various processes on P-v diagram.* 4. *Calculation of work done in various thermodynamic processes.* 5. *Calculation of enthalpy in solids, fluids and gas.* 6. *Determination the properties of dry air-water vapor mixtures, plot processes on a psychrometric chart, and analyze processes involving dry air-water vapor mixtures to perform energy and mass balances.* 7. *Applications of the conservation of mass, conservation of energy, and the first law of thermodynamics.* 8. *Review. First quiz.* 9. *Calculation of entropy in closed and open systems. Plot T-s diagrams.* 10. *Discussing of Applications of second law of thermodynamics.* 11. *Representation of common ideal power generation cycles (carnot, Rankine, otto, diesel cycles) on P-v, T-s diagrams. Calculation of possible and useful work; calculation of cycle efficiency.* 12. *Analyzing of refrigeration and heat pump systems, including single and multistage vapor compression cycles, and gas refrigeration cycles.* 13. *Basic modes of heat transfer; conduction, convection and radiation, and their application to simple situations.* 14. *Calculation of heat transfer through multilayer building assembly. Temperature diagram by steady-state heat flow. Calculation of heat loss from thermal insulated pipes.* 15. *Review, Second quiz.*
Accomplished learning outcomes	*THD_S1*
Means of verification, rules and criteria of assessment	*Passing quiz on exercises – a grade from exercises is an arithmetic average of formative grades. The share of the grade for the project exercises in the final grade of the subject is 50%.*

References:

Basic	1. *Van Ness H. C. 1969. Understanding thermodynamics. McGraw-Hill-Book, New York, USA, pp. 103.*

	2. *Potter C., Somerton W. 2006. Thermodynamics for engineers. Second edition. McGraw-Hill-Book, New York, USA, pp. 406.* 3. *Borgnakke C., Sonntag R.E. 2013. Fundamentals of Thermodynamics, Wiley, Hoboken, USA.*
Supplementary	1. *DOE fundamentals handbooks. 1992. Thermodynamics, heat transfer, and fluid flow, U.S. Department of Energy.*

Structure of learning outcomes

Area of academic study: R – Agricultural, forestry and veterinary sciences	0.0	ECTS **
Area of academic study: T – technical sciences	6.0	ECTS**

Structure of student activity

Contact hours	57	hrs.	2.3	ECTS**
Including: lectures	15	hrs.		
classes and seminars	30	hrs.		
consultations	10	hrs.		
participation in research	0	hrs.		
obligatory traineeships	0	hrs.		
participation in examination	2	hrs.		
e-learning	0	hrs.	0.0	ECTS**
student own work	93	hrs.	3.7	ECTS**

*Areas of academic study in the fields of: A – the arts; H – humanities; M – medical, sport and health sciences; N – natural sciences; P – biological sciences; R – agricultural, forestry and veterinary sciences; S – social studies; T – engineering and technology

** stated with an accuracy to 0.1 ECTS, where 1 ECTS = 25–30 hours of classes