STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Heat Engineering and Heat Measurements**		Code **1010102211010130183**
Field of study **Environmental Engineering Second-cycle**	Profile of study (general academic, practical) **(brak)**	Year /Semester **1 / 1**
Elective path/specialty **Heating, Air Conditioning and Air Protection**	Subject offered in: **Polish**	Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **full-time**	
No. of hours Lecture: **30** Classes: **15** Laboratory: **30** Project/seminars: **-**		No. of credits **6**
Status of the course in the study program (Basic, major, other) **(brak)**	(university-wide, from another field) **(brak)**	
Education areas and fields of science and art **technical sciences** **Technical sciences**		ECTS distribution (number and %) **6 100%** **6 100%**

Responsible for subject / lecturer:

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Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Mathermatics: differential and integral equations and their solutions. Physics at level 5KRK. Thermodynamics at level 6KRK.
2	**Skills**	Application of differential and integral description of physical phenomena, solution of differential equations. Thermodynamics: analysis of thermodynamic problems and realization of measurements and investigations at level 6 KRK
3	**Social competencies**	Awareness of the need of permanent updating and supplementing knowledge and engineering skills.

Assumptions and objectives of the course:

Extension of knowledge and skill of basic heat engineering and experimental techniques used in build and natural environmental engineering.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. Student gains a wider knowledge and skills concerning heat engineering and measurements needed for solving advanced thermodynamic problems in environmental engineering appearing in build and natural environment. (achieved during lectures, tutorials and laboratory exercises) - [K2_W03, K2_W04, K2_W07]

2. Student knows methods and thermal properties needed for theoretical and design solution of thermodynamic problems appearing in environmental engineering. (achieved during lectures and tutorials) - [K2_W03, K2_W04, K2_W07]

3. Student knows methods and thermal properties needed for theoretical and design solution of thermodynamic problems appearing in environmental engineering. (achieved during lectures and tutorials) - [K2_W03, K2_W04, K2_W07]

4. Student knows rules of calculation of energy balances, heat losses and heat efficiency concerning equipment and systems in environmental engineering. (achieved during lectures, tutorials and laboratory exercises) - [K2_W03, K2_W04, K2_W07]

5. Student knows an advanced knowledge concerning development tendencies and new achievements in heat equipment and processes in environmental engineering. (achieved during lectures and tutorials) - [K2_W03, K2_W04, K2_W07]

Skills:

1. Student can find and estimate information taken from literature and internet concerning heat engineering equipment appearing in environmental engineering. (achieved during lectures, tutorials and laboratory exercises) - [K2_U01, K2_U18]

2. Student can find adequate relationships describing analysed heat processes. (achieved during lectures and tutorials) - [K2_U01, K2_U18]

3. Student knows how determine thermodynamic properties needed for calculations. (achieved during lectures and tutorials) - [K2_U01, K2_U18]

4. Student can recognize and solve advanced design and operation problems occurred in heat equipment. (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

5. Student can critically estimate a design solution and recognize a danger hazard in erected and operated heat equipment. (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

6. Student can plan and realize operating tests and prototype investigations equipment appearing in environmental engineering. (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

7. Student can determine an accuracy and analyse obtained results of calculation and measurements. (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

8. Student can critically analyse obtained results of calculations and measurements and develop conclusions. (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

9. Student can develop a detailed energy balance, calculate heat efficiency and heat losses of analysed equipment. (achieved during lectures, tutorials and laboratory exercises) - [K2_U01, K2_U18]

Social competencies:

1. Student understand a team cooperation in solved problems. (achieved during lectures, tutorials and laboratory exercises) - [- K2_K03]

2. Student is aware of the range and limits of the used calculation methods and relationships as well as importance of possessed theoretical and practical knowledge. (achieved during lectures, tutorials and laboratory exercises) - [- K2_K03]

3. Student understands a need of examination and verification of results of used calculation and experimental methods.(achieved during lectures, tutorials and laboratory exercises) - [- K2_K03]

4. Student is aware of need of innovation. (achieved during lectures, tutorials and laboratory exercises) - [- K2_K03]

Assessment methods of study outcomes

Lecture (results W03, W04, W07, U01, U18)

The final exam consists of two parts:

Part 1: Test of understanding of fundamentals of heat engineering (3 to 5 questions).

Part 2: Test of competence conc. solving of heat engineering problems (1 to 3 problems).

In some cases an oral examination is used. Also an activity of students during lectures and tutorials is taken into account.

To pass each of the two parts of the exam (as well as to pass the tutorials) there is necessary to obtain at least 50% of the maximum points (max=20 points). The exam is passed if both part 1 and part 2 are passed. Corrected (Improved) is only this part which was failed.

Grading system:

0-9 points = 2,0 (failed)

10-12 points = 3,0 (sufficient)

13-14 points = 3,5 (sufficient plus)

15-16 points = 4,0 (good)

17-18 points = 4,5 (good plus)

19-20 points = 5,0 (very good)

Tutorials (results U01, U18)

45-minute of written final test at the end of semester.

Continuous assessment of student activity during each tutorial (reward of activity).

Laboratory training (exercises):

15 minute short entrance test before each laboratory training and final assessment of of the written report and eventual oral presentation of the results.

Course description

Introduction, subject contents. Thermodynamic system and control volume. International scale of temperature. Amount of substance. Ideal and real gas equation of state. Mass and energy conservation. Examples of gas mixtures: air, flues. Energy of the system, internal energy. Energy of fluid flow, enthalpy. Heat specific of ideal and real gas, model of semi ideal gas. Gibbs and Meyer equations. First law of thermodynamics. Second law of thermodynamics. Entropy, principle of increase of entropy. Typical thermodynamic processes. Work and heat of the thermodynamic process. Calculations of the entropy increases of ideal, semi ideal and real gases, entropy charts (T-s). Energy balance of the fluid flow machinery. Comparison of isentropic compression of ideal and real gases. Water vapour, processes of water vapour. Water vapour enthalpy chart. Properties of liquid and vapour water, tables, charts and computer program. Throttling of ideal gases, application of throttling process. Properties and processes of humid air, psychrometric chart, measurements of relative humidity. Combustion: properties of fuels, stoichiometric equations of combustion, excess of air, calculation and measurement of content of combustion fumes, dew point temperatures of flue gases, enthalpy of formation, calculation and measurements of higher and lower heating values. Adiabatic flame temperature. Efficiency of combustion chamber, control of combustion process. Typical thermodynamic cycles: Carnot, Otto, Diesel and Joule. Clausius-Rankine cycle, organic Rankine cycle (ORC cycles), power and heat cogeneration systems. Linde cycle, refrigeration and heat pump coefficient of performance (COP). Application of thermodynamic relations. Adiabatic throttling, Joule-Thomson effect, calculation of the Joule-Thomson coefficient. Maximum reversible work, definition and application of exergy. Measurement of temperature of high velocity gas (total and static enthalpy). Principle of the thermodynamic gas dynamics, Bendemann and de Lavala nozzles, application to the flow rate measurements. Pressure losses in short and long pipes.

Teaching method:

Classical lecture with elements of conversation

Tutorials ? solving problems method

Laboratory exercises ? teaching by experimentation

Basic bibliography:

1. SZARGUT J., Termodynamika techniczna. Wyd. Politechniki Śląskiej, Gliwice, 2000

2. KALINOWSKI E., Termodynamika. Skrypt Politechniki Wrocławskiej, Wrocław, 1994

3. SMUDSZ R., WILK J., WOLAŃCZYK F., Termodynamika. Repetytorium. Oficyna Wyd. Politechniki Rzeszowskiej, Wyd. III, stron 115, Rzeszów, 2009 (cena 12 zł)

4. WIŚNIEWSKI S., Termodynamika techniczna. WNT, Warszawa 1993 (463 strony)

5. OCHĘDUSZKO St., Termodynamika stosowana. WNT, Warszawa, 1964

6. Pomiary cieplne, T. 1 i T. 2, Praca zb. (Red. T.R. Fodemski), WNT, Warszawa, 2001

7. SZARGUT J., GUZIK A., GÓRNIAK H.: Zadania z termodynamiki technicznej, Wyd. Pol. Śląskiej, Gliwice 2008

8. OLEŚKOWICZ-POPIEL C., WOJTKOWIAK J., Właściwości termofizyczne powietrza i wody ? przeznaczone do obliczeń przepływów i wymiany ciepła. Wyd. Polit. Poznańskiej, Poznań, 2010

9. OLEŚKOWICZ-POPIEL C.,AMANOWICZ Ł., Eksperymenty w technice cieplnej. Wyd. Polit. Poznańskiej, Poznań, 2016

Additional bibliography:

1. RUBIK M., Pompy ciepła, Wyd. II, Ośrodek Informacji. Technika Instalacyjna w Budownictwie, Warszawa 1999

2. SONNTAG R.E., BORGNAKKE C., VAN WYLEN G.J., Fundamentals of Classical Thermodynamics, SI Version, 6th Edition, John Wiley and Sons, Inc., U S A, 2003 (HC 245,-zł)

3. SONNTAG R.E., BORGNAKKE C., Introduction to Engineering Thermodynamics, 2nd Edition, John Wiley and Sons, Inc., U S A, 2007

4. SCHMIDT P., BAKER D., EZEKOYE O., HOWELL J., Thermodynamics. An Integrating Learning System. International Edition., John Wiley and Sons, Inc., U S A, 2006 (205,-zł)

5. CENGEL Y.A., BOLES M.A., Thermodynamics. An Engineering Approach. 6 Edition (SI Units), McGraw-Hill Higher Education, 2007

Result of average student's workload

Activity	Time (working hours)
1. Lecture (contact hours)	30
2. Tutorials (contact hours, practical training)	15
3. Laboratory training (exercises) (contact hours, practical training)	30
4. Preparation to tutorials (autonomus learning)	20
5. Development of laboratory reports (autonomus learning)	17
6. Consultations (contact hours)	3
7. Preparation for the final test of tutorials (autonomus learning)	15
8. Preparation to examination test (autonomus learning)	20

Student's workload

Source of workload	hours	ECTS
Total workload	150	6

Contact hours	80	3
Practical activities	45	2