Subject programme

1. Subject name / subject module: **Thermodynamics**
2. Lecture language: **English**
3. The location of the subject in study plans:
   - Area or areas of the studies: **Computer Control Systems Engineering**
   - Degree of the studies: **2nd degree studies**
   - Field or fields (implementation of effects standard): **Mechatronics**
4. Supervision of subject implementation:
   - The Institute / Another unit: **The Institute of Informatics and Mechatronics**
   - The person responsible for the subject: **Gireń Bolesław, dr hab. inż.**
   - People cooperating in the development of the programme of the subject:
5. The number of hours and forms of teaching for individual study system and the evaluation method

Teaching activities with the tutor																						Total
Form of classes / Mode of study		SOW	ECTS	Classes	SOW	ECTS	...	SOW	ECTS	...	SOW	ECTS	...	SOW	ECTS	...	SOW	ECTS	...	SOW	ECTS	ECTS
Full-time studies				26	49	3																3
Part-time studies																						
Credit rigor	...			exam																		

6. Student workload – ECTS credits balance
   1 ECTS credit corresponds to 25-30 hours of student work needed to achieve the expected learning outcomes including the student's own work

Activity (please specify relevant work for the subject)	**Hourly student workload (full-time studies/part-time studies)**
Participation in classes	**26**
Independent study of the subject – preparing to the exam	**47**
Participation in an exam / graded assignment / final grading	**2**
Total student workload	**75**
ECTS credits	**3**
* Student's workload related to practical forms	**75**
Student's workload in classes requiring direct participation of academic teachers	**26**

7. Implementation notes: recommended duration (semesters), recommended admission requirements, relations between the forms of classes:

   None

   Recommended duration of the subject is taken from the course plan.
8. Specific learning outcomes – knowledge, skills and social competence

Specific learning outcomes for the subject		Form	Teaching method	Methods for testing of (checking, assessing) learning outcomes
Outcome symbol	Outcome description			
Knowledge				
K_W01	**Student understands the fundamentals of thermodynamics. Student gets knowledge on the rules which govern the thermodynamic agents, their transformations and heat exchange. Student has got knowledge on various thermodynamic systems and the operating cycles met in practical life. Student has got familiar with measurement methods of thermodynamic parameters as well as on calculation methods for heat engines and heat pumps. Student understands thermodynamic processes and due interpretations of chemical and physical transformations from thermodynamical point of view.**	**Classes**	**Inquiry methods**	**Exam**

Skills				
K_U03	Student can perform thermal analysis on behaviour and performance of thermodynamical systems. Student has ability to make energy balances and calculate the thermodynamic parameters, including the fields of temperature. Student has ability to recognized the causality - relation between the cause and the effect. Student has skills of heat flow, radiation and convection calculations and to solve some chosen thermodynamic problems. Student is able to apply energy balance to systems and control volumes, in cases involving heat and work interactions. Student is able to evaluate the performance of energy conversion devices.	Classes	Inquiry methods	Exam

9. Assessment rules / criteria for each form of education and individual grades

Activity	Grades	Calculation	To Final
Activity during classes	x	x*15%	0.15*x
Attendance	On 80% of all classes	x*10%	0.5*y
Exam	x	x*75%	0.75*x

10. The learning contents with the form of the class activities on which they are carried out

(Classes)

Thermodynamic terms; Internal energy; Reversible and actual work; Pressure and temperature; Specific heat; Thermodynamic Equilibrium State, path and process. Displacement work and other modes of work; P-V diagram;Quasi-static, reversible and irreversible processes; Heat; Conduction, convection and radiation heat transfer; Fourier law, Newton formula, Stefan-Boltzmann law; Heat and work transfer, definition and comparison, sign convention. Properties of state - enthalpy, entropy; First law of thermodynamics; Constant volume process; Constant pressure process; Constant temperature process; Adiabatic process; Polytropic process; Diesel cycle; Otto cycle; Carnot cycle, Stirling and Ericson cycle; Second law of thermodynamics; Entropy; Clausius inequality; Clausius and Kelvin statement of second law; T-S diagram, TdS Equations, entropy change for – pure substance, ideal gases – different processes, principle of increase in entropy; Concepts of availability energy and second law efficiency; Phase transformations of the homogenous substances; Constant pressure vaporization; saturated steam, dry, wet and overheated; Power and refrigeration cycles; Rankine cycle; Vapor compression cycle; Alternative refrigeration cycles; Non-reacting gas mixtures and applications; Air conditioning and air conditioning processes; Chemical reacting mixtures and applications; Fuel combustion; Adiabatic Flame Temperature; Ideal and real gas comparison- equations of state for ideal and real gases; Maxwell relations; Difference and ratio of heat capacities; Energy equation; Joule-Thomson Coefficient; Clausius Clapeyron equation; Phase Change Processes. Simple Calculations; Phase changes of substances; Van der Vaals equation; Compressors; heating pumps.

11. Required teaching aids

Exercises - a room adapted for conducting classes in the form of exercises / workshops, multimedia projector

12. Literature:

a. Basic literature:

Vladislav Čápek, Daniel P. Sheehan: Challenges to The Second Law of Thermodynamics. Springer, 2005. e-Book.

a. Supplementary literature:

Fundamentals of Engineering Thermodynamics, 8th ed., by Moran, Shapiro, et al., John Wiley and Sons, 2014

Energy, Entropy and Engines : An Introduction to Thermodynamics by Sanjeev Chandra, John Wiley and Sons, 2016

Basic and Applied Thermodynamics by PK Nag, MCGRAW HILL INDIA.

Thermodynamics for Engineers by Kroos & Potter, Cengage Learning.

Rayner Joel, Basic Engineering Thermodynamics, Pearson 1997.

M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamics, Wiley2018.

Refrigeration and Air Conditioning by C P Arora, MCGRAW HILL INDIA.

b. Internet sources:

R.K.Rajput, Engineering Thermodynamics, https://uowa.edu.iq/filestorage/file_1551541671.pdf

13. Available educational materials divided into forms of class activities (Author's compilation of didactic materials, e-learning materials, etc.)

14. Teachers implementing particular forms of education

Form of education	Name and surname
1. Classes	Gireń Bolesław, dr hab. inż.