FACULTY OF MECHANICAL AND POWER ENGINEERING

SUBJECT CARD

Name of subject in Polish **Modelowanie matematyczne instalacji energetycznych**
Name of subject in English: **Mathematical Modeling of Energy Generation Installations**
Main field of study (if applicable): **Power engineering**
Specialization (if applicable):
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code **W09ENG-SM0038W**
Group of courses **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		60		
Number of hours of total student workload (CNPS)	90		90		
Form of crediting	Examination		crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	3		3		
including number of ECTS points for practical classes (P)	0		3		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,5		2,25		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Skills to create three dimensional geometry in engineering software.
2. The extent of knowledge in heat transfer and fluid mechanics fields.

\

SUBJECT OBJECTIVES

C1 – providing knowledge about methods of thermal-flow processes numerical simulationsC2 – providing knowledge about energetic systems optimizing methods

C3 – developing skills of creating mesh for defined geometry

C4 - developing abilities of performing numerical calculations for simple and complex thermal-flow processes

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 – knowledge about equations describing heat transfer and fluid flow

PEU_W02 - knowledge of turbulence and their models

PEU_W03 – knowledge about numerical methods of solving heat transfer problems

PEU_W04 – acquaintance with numerical methods of solving steady and transient thermal-flow processes

PEU_W05 - knowledge about boundary and initial conditions applied during thermal-flow processes analyses

PEU_W06 - knowledge about most often occurring CFD numerical errors and their impact on calculations

PEU_W07 – basics of LES method

PEU_W08 – acquaintance with methods of energetic systems optimizing

relating to skills:
PEU_U01 – skills to create geometry and numerical mesh

PEU_U02 – ability to evaluate influence of mesh density on numerical results

PEU_U03 - skills to carry out numerical calculations of steady and unsteady heat transfer and fluid flow

PEU_U04 – ability to perform numerical calculations of steady and unsteady processes in energetic machines

PEU_U05 - ability to analyze numerical results and drawing proper conclusions

PROGRAMME CONTENT

Lecture		Number of hours
Lec1	Organizing issues. Introduction to Computational Fluid Dynamics (CFD).	2
Lec2	Description of heat transfer and fluid mechanics equations.	2
Lec3	Turbulence. Models of turbulence.	2
Lec4	Finite volume method for steady heat conduction.	2
Lec5	Finite volume method for steady convection – conduction issues.	2
Lec6	Algorithm for pressure and velocity fields calculations for fluid flow.	2
Lec7	Iteration methods for solving algebraic systems of equations.	2
Lec8	Finite volume method for unsteady fluid flow.	2
Lec9	Types of boundary conditions and their application.	2
Lec10	Types of numerical errors during CFD simulations and their influence on calculations.	2
Lec11	Introduction to Large Eddy Simulation (LES) method.	2
Lec12	Application and examples of LES.	2
Lec13	Optimizing of energy generation installations – minimizing of entropy production.	2
Lec14	Optimizing of energy generation installations – egzergy analysis.	2
Lec15	Examples of energetic systems optimizing.	2
	Total hours	**30**

Laboratory	Number of hours

Lab 1	Course matters (input, output, grading). Introduction to the course. Overview of the tools used (Matlab, CFX, Ansys Meshing). Lumped thermodynamic model of an energy installation. Preliminary system analysis.	4
Lab 2 Lab 3	Flow through isolated pipeline. Calculating CHT problem, solving for pressure losses. Testing numerical results stability and computational cost against mesh parameters.	8
Lab 4	Results post-processing and visualization. Report generation. Simple scripting in data manipulations.	4
Lab 5 Lab 6	CFD calculations of a heat exchanger. Base geometry preparation and discretization of its section. CFD calculations, results presentation. Exergy analysis.	8
Lab 7	HE design parametrization and optimization against entropy generation. Report editorial.	4
Lab 8 Lab 9	CFD calculations of a pump. Base geometry preparation and discretization. CFD calculations and results presentation. CFX-TurboGrid.	8
Lab 10	Pump geometry modifications. CFD calculations to obtain optimal solution. Report editorial.	4
Lab 11	CFD calculations of a heater/cooler. Geometry generation and discretization. CFD calculations and results presentation. Report editorial	4
Lab 12 Lab 13	CFD calculations of a compressor/expander. Gas machine type selection, geometry generation and its discretization. CFD calculations and results presentation. Report editorial.	8
Lab 14 Lab 15	Energy system final model implementation. Basic thermoeconomic analysis. Discussion over possible efficiency improvements. Final report editiorial.	8
	Total hours	60

TEACHING TOOLS USED

N1. Multimedia presentation.
N2. Software for geometry and numerical mesh generation, for example ANSYS Spaceclaim, ANSYS Meshing.
N3. Software for CFD simulation for example ANSYS CFX.
N4. Consultation hours.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT - lecture

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
C	PEU_W01- PEU_W08	Exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT - laboratory

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_U01, PEU_U02, PEU_U05	Report no. 1

F2	PEU_U01, PEU_U03- PEU_U05	Report no. 2
F3	PEU_U01, PEU_U03- PEU_U05	Report no. 3
F4	PEU_U01, PEU_U03- PEU_U05	Report no. 4
F5	PEU_U01, PEU_U03- PEU_U05	Report no. 5
F6	PEU_U05	Final report
P=0,1F1+0,15F2+0,15F3+0,15F4+0,15F5+0,3F6		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Patankar S., Numerical Heat Transfer And Fluid Flow, McGraw-Hill, Book Company, 1980.

[2] Versteeg H. K., Malalasekera W., An Introduction to Computational Fluid Dynamics. The Finite Volume Method, 2nd ed., Pearson Education Limited, 2007.

[3] Anderson J. D., Computational Fluid Dynamics. The Basics with Applications., McGraw-Hill Book Company, 1995.

[4] Jaworski Z., Numeryczna mechanika płynów w inżynierii chemicznej i procesowej (in Polish).

SECONDARY LITERATURE:

[1] Tannehill J. C., Anderson D. A., Pletcher R. H., Computational Fluid Mechanics And Heat Transfer, Taylor & Francis, 1997.

[2] Ferziger J. H., Peric M., Computational Methods For Fluid Dynamics, 3rd ed., Springer, 2007.

[3] Hoffmann K. A., Chiang S. T., Computational Fluid Dynamics, 4th edition, vol. I,II,III, Engineering Education System, 2000.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Sławomir Pietrowicz, slawomir.pietrowicz@pwr.edu.pl