Advanced data processing

Faculty of	**Mechanical and Power Engineering**
Name in English	**Advanced data processing**
Name in Polish	**Zaawansowane przetwarzanie danych**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**wybieralny**
Subject code	**W09ENG-SM2345**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	25		50		
Form of crediting	Colloquium		Colloquium		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic understanding of the programming process
2.	Knowledge of basic phenomena in thermodynamics and fluid mechanics and their mathematical modeling

SUBJECT OBJECTIVES

C1	Provide knowledge on how to conduct automated measurement methods
C2	Provide knowledge of methods for analysing measurement data
C3	Providing knowledge on the verification of mathematical models

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Knowledge of programming in simulation conditions
PEU_W02	Knowledge of programming in real conditions
PEU_W03	Knowledge of selecting and using appropriate measurement systems
relating to skills:	
PEU_U01	Ability to program in LabView™
PEU_U02	Ability to use Diadem™ software
PEU_U03	Ability to connect the appliance in practice
PEU_U04	Ability to model and verify a mathematical model
relating to social competences:	
PEU_K01	Ability to work together in a small group (of two or three people)

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Organizing issues. Introduction to measurement automation and data analysis.	1
Lec2	LabView™ environment, data types, clustered arrays etc. Debugging and error handling capabilities.	2
Lec3	Implementation of loops and structures to facilitate programming.	2
Lec4	Preliminary analysis of the system for measurement. Selection of appropriate equipment. Programming of acquisition systems. File operations.	2
Lec5	'Live' data processing and presentation. Advanced data processing (filters, transforms) "live" and postprocessing.	2
Lec6	Global and local variables.	2
Lec7	Synchronisation and communication.	2
Lec8	Passing classes.	2
Suma godzin		15

Laboratory		Number of hours
La1	Course issues (input, output, assessment). Introduction to the course. Overview of tools used (LabView, Diadem, National Instruments hardware). (Computer Classes)	2
La2	Introduction to the LabView™ environment, basics of programming in graphical languages. (Computer Classes)	2
La3	Preparation of data-acquisition programme using simulation of measuring devices. Preparation of UI screen, basic data processing. (Computer classes)	2
La4		2
La5		2
La6	Advanced data processing, signal filtering, spectrum analysis. (Computer classes)	2
La7		2
La8	Development of measurement software for the thermodynamics test stand. Postprocessing of measurement data. (Laboratory classes)	2
La9		2
La10	Development of measurement software for the thermodynamics and heat transfer test stand. Processing of measurement data. Analysis incorporating and verifying the mathematical model. (Laboratory classes)	2
La11		2
La12		2
La13		2
La14		2
La15	Organisational and knowledge enhancement laboratory classes.	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Multimedia presentations
N2	Computers with installed LabView™ software
N3	Laboratory workstations including National Instruments™ components

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01	Report 1 (Computer Classes)
F2	PEU_U02, PEU_U04, PEU_K01	Report 2 (Laboratory Classes)
F3	PEU_U03	Activity during Laboratory Classes
C1 (Laboratory)	PEU_U01 – PEU_U03	2/5 F1 + 2/5 F2 + 1/5 F3
C2 (Lecture)	PEU_W01 – PEU_W03	Colloquium

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	LabView Application Development and Design Guidelines
2	Hands-On Introduction to LabVIEW for Scientists and Engineers, Dr John Essick
3	Control Systems Engineering Paperback, Norman S. Nise
4	Środowisko LabVIEW w eksperymencie wspomaganym komputerowo, Wiesław Tłaczała
Secondary literature	
1	LabVIEW - The Ultimate CLAD Preparation Book, Pierre FIÉVET
2	Software Engineering Approach to LabVIEW, Jon Conway
3	LabVIEW w praktyce, Marcin Chruściel

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

Imię i nazwisko:	Andrzej Nowak
E-mail:	an.nowak@pwr.edu.pl

Advanced numerical modeling using OpenFOAM

Faculty of	**Mechanical and Power Engineering**
Name in English	**Advanced numerical modeling using OpenFOAM**
Name in Polish	**Zaawansowane modelowanie numeryczne w środowisku OpenFOAM**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2343**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Preliminary knowledge related to numerical modelling including basic discretization schemes.

SUBJECT OBJECTIVES

C1	Introduction to the OpenFoam numerical toolbox and OpenFoam programming.
C2	Introduction to basic and advanced numerical models implemented in OpenFoam.
C3	Developing skills to define new mathematical and numerical models.
C4	Developing skills to implement new numerical and mathematical models in OpenFoam.
C5	

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	knows and understands basics of finite volume discretization and its specifics in the Computational Fluid Dynamics
PEU_W02	knows and understands the structure of OpenFoam numerical toolbox and basics of OpenFoam programming
PEU_W03	knows and understands advanced numerical models including: conjugate heat transfer, flow with mixing and reactions
PEU_W04	knows and understands dynamics mesh concepts including Arbitrary Mesh Interface
PEU_W05	knows and understands basic and more complex boundary conditions
relating to skills:	
PEU_U01	is able to: use the basic and advanced numerical models offered by the OpenFOAM

PEU_U02	is able to: use the basic and advanced preprocessing and postprocessing utilities offered by the OpenFoam environment
PEU_U03	is able to: use the ParaView software to visualise the numerical data
PEU_U04	is able to: implement new equations and to develop the exiting OpenFoam solvers
PEU_U05	is able to: implement new numerical models in the OpenFoam
PEU_U06	is able to: define numerical models with dynamic mesh
PEU_U07	is able to: define numerical multiphase numerical models

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Summary of conservation equations and their representation by partial differential equations. Introduction to OpenFoam software.	2
Wy2	Introduction to OpenFoam software including: the OpenFoam structure, available numerical models and basic pre- and post-processing utilities.	2
Wy3	Thermodynamic and transport models available in OpenFoam. Introduction to conjugate heat transfer modelling and detailed presentation of a corresponding flow example.	2
Wy4	Introduction to modelling of flow with multiple spices and flow with chemical reactions. Detailed presentation of a corresponding numerical example based on lecturer own research.	2
Wy5	Introduction to Finite Volume Method and basic methods of discretization used in CFD.	2
Wy6	Introduction to OpenFoam programming #1: implementation of Burgers equation. Discussion of consequences of non-linear nature of the Burgers equation.	2
Wy7	OpenFoam programming #2: adding a new PDE equation to an existing solver, compilation and usage.	2
Wy8	OpenFoam programming #3: implementation of variable viscosity in an existing model, explanation of definition of new numerical model with the implemented viscosity model. Discussion of influence of the new model on the flow.	2
Wy9	Introduction to complex boundary condition.	2
Wy10	OpenFoam programming #4: creation of a new numerical library by definition and implementation of Casson viscosity model. Presentation of its usage and consequences in the flow.	2
Wy11	Introduction to turbulence and turbulence modelling: RANS equations, Eddy viscosuty.	2
Wy12	Introduction to the concept of wall functions and basics of their implementation.	2
Wy13	Modelling of wind power plant: linear and angular momentum theory. Introduction to usage of additional source terms in numerical modelling.	2
Wy14	OpenFoam programming #5: definition and implementation of heat transfer in superfluid helium	2
Wy15	Final test of the lecture	2
Suma godzin		30

laboratory		Number of hours
La1	Introduction to the OpenFoam, discussion of its structure and installation. First Example: Lid-driven cavity flow and flow in a channel.	2
La2	Usage of complex boundary conditions (derived from basic BCs) based on T-junction example.	2
La3	Usage and definition of conjugate heat transfer model. Running calculation in parallel mode.	2
La4	OpenFoam programming #1: adding a new PDE equation to existing solver, compilation and usage.	2
La5	OpenFoam programming #2: step-by-step implementation of a variable viscosity in an existing solver. Exercise: modelling of a flow of two miscible fluids with different viscosities.	2
La6	Definition of a numerical model with dynamic mesh based on a sloshing tank example and a rigid body motion.	2
La7	Dynamic mesh motion using Arbitrary Mesh Interface	2
La8	OpenFoam programming #3: step-by-step implementation of a new viscosity model (Casson model).	2
La9	Usage of the new viscosity model implemented during Lab 8 in a flow in channel and comparison of the results with different viscosity models.	2
La10	Definition and running of numerical model of a flow of reacting mixture including: combustion, reactions and mixing.	2
La11	Adapting the reactingFoam for a passive gases mixing.	2

La12	Definition of a numerical model of helium discharge and its propagation in a tunnel.	2
La13	Adding new physical models as source terms (using fvOptions). Modelling of wind turbine as Actuation Disc Source.	2
La14	Adding new physical models as source terms (using fvOptions). Modelling of porosity.	2
La15	Presentation of individual student's projects.	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Traditional lecture with a use of slides
N2	Laboratories – computational exercises
N3	Laboratories – individual solution of numerical problems using OpenFoam
N4	Consultation
N5	Independent work – individual study , homework and final project

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEK_W01 -- PEK_W05	Final test
C1	PEK_W01 -- PEK_W05	Homework
C2	PEK_U01 -- PEK_U07	Exercises during laboratory classes

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	F Moukalled, L Mangani, M Darwish; The Finite Volume Method in Computational Fluid Dynamics An Advanced Introduction with OpenFOAM and Matlab
2	User Guide, Tutorial Guide, Programmers Guide, https://www.openfoam.com/documentation/
Secondary literaturę	
1	OpenFOAM wiki: http://openfoamwiki.net/index.php/Main_Page
2	J Ferziger, M Peric, R Street; Computational Methods for Fluid Dynamics

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

Imię i nazwisko:	Ziemowit Malecha
E-mail:	Ziemowit.malecha@pwr.edu.pl

Air conditioning systems

Faculty of	**Mechanical and Power Engineering**
Name in English	**Air conditioning systems**
Name in Polish	**Systemy klimatyzacyjne**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2362**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	25		25		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		0,76		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Technical Thermodynamics
2.	Fluid Mechanics

SUBJECT OBJECTIVES

C1	Acquisition of practical knowledge, regarding air-condition systems, their design and application.
C2	Development of skills how to design and analyze air-conditioning systems.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge of rules and standards for design and operation of air-condition systems
PEU_W02	Has knowledge of the design of air-conditioning installations
relating to skills:	
PEU_U01	Can determine the basic parameters of the air-conditioning system and indicate characteristic points of refrigeration cycle.
PEU_U02	Can conclude from the measurements of air-conditioning system operating parameters

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Lec1	Overview of the lecture. Introduction. Air-conditioning processes. Air flow and thermal comfort.	2

Lec2 – Lec7	Air-conditioning processes thermodynamic basics. Humid air properties. Psychrometric diagram. Heating, cooling and dehumidifying. Air mixing. Heating and cooling load calculations. Heating and humidifying systems. Influence of air relative humidity level on energy demand of heating and cooling systems. Refrigeration cycle for air-conditioning. Required temperature levels. Convective and radiant heat loads. Piping connection methods in air-conditioning systems. Heat recovery. Heat exchangers for air-conditioning. Thermal storage systems (cold water, ice slurry, ice harvesting, PCM).	12
Lec8	Colloquium	1
Total hours		15

laboratory		Number of hours
La1 – La7	Thermodynamic changes of moist air inside the air washer; adiabatic cooling. Dehumidification of moist air. Measurements of working parameters of the split air conditioner. Testing the ducted system air conditioning at varying load. Measurements of working parameters of the countercurrent flow recuperative heat exchanger. Measurements of working parameters of the spiral countercurrent flow recuperative heat exchanger. Testing the portable air conditioner	2
La8	Corrective and supplementary classes	1
Total hours		15

TEACHING TOOLS USED	
N1	Lecture with presentation.
N2	Laboratory – discussion of problems.
N3	Self-study – study and preparation for the final colloquium.
N4	Office hours.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01 – PEU_W02	Mark of the colloquium
C2	PEU_U01 – PEU_U02	Reports from laboratory classes

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	2009 ASHRAE Handbook - Fundamentals (SI Edition), © 2009 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
2	2011 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning Applications (SI Edition), © 2011 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
3	ASHRAE GreenGuide - The Design, Construction, and Operation of Sustainable Buildings (3rd Edition), © 2010 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
4	Vedavarz A., Kumar S., Hussain M.I., HVAC - The Handbook of Heating, Ventilation and Air Conditioning for Design and Implementation., © 2007 Industrial Press
Secondary literature	
1	Farida M.M., Khudhaira A.M., Razackb S.A.K., Al-Hallajb S., A review on phase change energy storage: materials and applications., Energy Conversion and Management, Volume 45, Issues 9–10, June 2004, Pages 1597–1615
2	Sharmaa A., Tyagib V.V., Chena C.R., Buddhib D., Review on thermal energy storage with phase change materials and applications, Renewable and Sustainable Energy Reviews, Volume 13, Issue 2, February 2009, Pages 318–345
3	U.S. Department of Energy, Air Distribution System Design: Good Duct Design Increases Effciency

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

Name and surname:	Bogusław Białko
E-mail address:	boguslaw.bialko@pwr.edu.pl

Cryogenic systems and applied sperconductivity

Faculty of	**Mechanical and Power Engineering**
Name in English	**Applied Cryogenics in Power Engineering**
Name in Polish	**Zastosowania kriogeniki w energetyce**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2361**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,28				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge of issues concerning thermodynamics basis of cryogenics and low temperature physics
2.	Knowledge of the basics of heat transfer and fluid mechanics
3.	Knowledge of the basics of electricity and magnetism

SUBJECT OBJECTIVES

C1	providing information about the use of gas and cryogenic technologies in industry and energetics
C2	providing information about the technologies of liquefied hydrogen and liquefied natural gas
C3	providing information about the industrial technologies of gas mixture separations
C4	providing information about superconductivity phenomenon and its application in energetics
C5	providing information about conventional and cryogenic-based energy storage systems
C6	providing information about fusion reactors, possible fuels and the needs for the cryogenic technologies use

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	has knowledge on the use of gas and cryogenic technologies in industry and energetics
PEU_W02	has knowledge on the technologies of liquefied hydrogen and liquefied natural gas
PEU_W03	has knowledge on the industrial technologies of gas mixture separations
PEU_W04	has knowledge on superconductivity phenomenon and its application in energetics
PEU_W05	has knowledge on conventional and cryogenic-based energy storage systems,
PEU-W06	has knowledge on fusion reactors, possible fuels and the needs for the cryogenic technologies use

relating to social competences:	
PEU_K01	is able to active listening

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction, course content overview	2
Wy2	Introduction to LNG technology	2
Wy3	LNG fuel systems	2
Wy4	LNG big Infrastructure	2
Wy5	Liquid hydrogen technology	2
Wy6	Liquid hydrogen fuel systems	2
Wy7	Gas mixtures separation	2
Wy8	Oxy-fuel technology in power generation and metallurgy	2
Wy9	Cryogenic exergy recovery systems	2
Wy10	Superconducting power cables and power grid auxiliary equipment	2
Wy11	Superconducting motors and generators	2
Wy12	Conventional and cryogenic energy storage systems	2
Wy13	Cryogenics in fusion reactors	2
Wy14	He3 resources and recovery systems	2
Wy15	Test	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Information lecture
N2	Multimedia presentation
N3	Self-work, self-studies and preparation for the final test
N4	Individual discussion with students and consultancies

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C	PEU_W01 -PEU_W06 PEU_K01	Final test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	S. Mokhatab at. al., *Handbook of Liquefied Natural Gas*, Elsevier Inc., 2014, ISBN 978-0-12-404585-9
2	W. Peschka, *Liquid Hydrogen - Fuel of the Future*, Springer-Verlag/Wien, 1992, ISBN978-3-7091-9128-6
3	Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker, USA.2005
4	Chorowski M., Kriogenika, podstawy i zastosowania, IPPU MASTA, Gdańsk 2007
5	A.R. Jha, Cryogenic Technology and Applications, Elsevier, USA, 2008
6	P. J. Lee, Engineering Superconductivity, Wiley-IEEE Press; 1 edition, 2001
7	A. U. Schmiegel, Energy Storage Systems, Oxfor University Press, 2023
Secondary literature	
1	R.C. Scurlock, Low-Loss Storage and Handling of Cryogenic Liquids: The Application of Cryogenic Fluid Dynamics, Kryos Publications, United Kingdom, 2006
2	G. Ventura, L. Risegari, The Art of Cryogenics, Elsevier, USA, 2008
3	Advances in Cryogenic Engineering, Transactions of the Cryogenic Engineering Conferences

4	W. Buckel, R. Kleiner, Superconductivity: Fundamentals and Applications, Wiley-VCH, 2004

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

Imię i nazwisko:	Jarosław Poliński
E-mail:	jaroslaw.polinski@pwr.edu.pl

Applied mathematics

Faculty of	**Mechanical and Power Engineering**
Name in English	**Applied mathematics**
Name in Polish	**Matematyka stosowana**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2331**
Group of courses	**NO**

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	50	50			
Form of crediting	Egzamin	Zaliczenie			
For group of courses mark final course with (X)					
Number of ECTS points	2	2			
including number of ECTS points for practical (P) classes		2			
including number of ECTS points for direct teacher-student contact (BU) classes	1,44	1,28			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic knowledge from differential and integral calculus
2.	Basic knowledge from algebra and vector analysis
3.	Basic knowledge from numerical methods

SUBJECT OBJECTIVES

C1	Presentation of selected ordinary and partial differential equations necessary to understand the mathematical description of physical phenomena occurring in devices and technical processes.
C2	Familiarization with the techniques of solving selected ordinary and partial differential equations with the use of analytical and numerical methods.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Student understands how the physical aspect of processes occurring in technology is described mathematically in the form of algebraic and differential equations.
PEU_W02	When dealing with a mathematical problem (e.g. an algebraic or differential equation), student distinguishes between exact and approximate solutions and understands the relationships between them.
relating to skills:	
PEU_U01	Student can indicate equations (algebraic or differential) describing physical phenomena in the studied technical processes.
PEU_U02	Student is able to select a correct tools to solve an identified mathematical problem.

PEU_U03	Student is able to solve ordinary or partial differential equations using appropriate analytical and numerical methods, assess their accuracy and interpret the physical and technical meaning of the obtained results.
relating to social competences:	
PEU_K01	-

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1-Wy4	Ordinary differential equations of the first order. Analytical methods of solving them. Selected numerical methods used to solve first order ordinary differential equations - examples of application.	8
Wy5-Wy7	Ordinary linear differential equations of the second order. Analytical methods of solving them. Selected numerical methods used to solve ordinary differential equations of the second order - examples of application.	6
Wy8	Second order partial differential equations. Canonical form. Fourier series.	2
Wy9-Wy10	Parabolic equations. Analytical methods of solving them. Selected numerical methods used to solve parabolic equations - examples of application.	4
Wy11-Wy12	Elliptic equations. Analytical methods of solving them. Selected numerical methods used to solve elliptic equations - examples of application.	4
Wy13-14	Hyperbolic equations. Analytical methods of solving them. Selected numerical methods used to solve hyperbolic equations - examples of application.	4
Wy15	An example of solving ordinary and partial differential equations using the functions available in the Matlab software.	2
Suma godzin		30

classes		Number of hours
Cw1-Cw4	Ordinary differential equations of the first order - methods of solving them and examples of their application.	8
Cw5-Cw7	Linear ordinary differential equations of the second order - methods of solving them and examples of their application.	6
Cw8	Canonical form - solving tasks. Fourier series - examples of application.	2
Cw9-Cw10	Parabolic equations - examples of application.	4
Cw11-Cw12	Elliptic equations - examples of application.	4
Cw13-Cw14	Hyperbolic equations - examples of application.	4
Cw15	Written test	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Lecture with the use of multimedia (presentation - slides).
N2	Calculation exercises supported by software.
N3	Consultation

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P1	PEU_W01- PEU_W02	Written exam
P2	PEU_U01- PEU_U03	Written test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	M. Abell, J. Braselton: *Differential Equations with Mathematica*, Elsevier 2004
2	J. Mathews, K. Fink: *Numerical Methods Using MATLAB*, Pearson Education 2004
3	W. Cheney, D. Kincaid: *Numerical Mathematics and Computing*, Thomson Brooks 2008
Secondary literature	
1	G. Dahlquist, A. Bjorck: *Numerical Methods in Scientific Computing*, SIAM 2007

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

Imię i nazwisko:	Paweł Regucki
E-mail:	pawel.regucki@pwr.edu.pl

Artificial intelligence

Faculty of	**Mechanical and Power Engineering**
Name in English	**Artificial intelligence**
Name in Polish	**Sztuczna inteligencja**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2349**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	25		25		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		0,76		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	differential equation course
2.	computer programming course
3.	control systems course

SUBJECT OBJECTIVES

C1	mastering the methods of artificial intelligence with applications to energy and control systems

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	student is familiar with the artificial neural networks theory
PEU_W02	student is familiar with the fuzzy logic theory
PEU_W03	student is familiar with the genetic algorithms theory
relating to skills:	
PEU_U01	student knows how to use artificial neural networks in practical problems
PEU_U02	student knows how to use fuzzy logic in practical problems
PEU_U03	student knows how to use genetic algorithm in practical problems

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	**How our brain works** 1.1 Few surprises about brain 1.2 Scanning the brain 1.3 A journey through the brain 1.4 Brain functions 1.5 Brain cells 1.6 Nerve impulses 1.7 Brain mapping and simulation 1.8 What is consciousness?	1
Wy2	**History and present day of artificial intelligence** 2.1 Brief history of intelligent systems 2.2 Biological and cognitive paradigms 2.3 Essential characteristics of intelligence 2.4 Philosophical questions about artificial intelligence 2.5 Acquiring knowledge, ageing behaviour and regulation 2.6 Biological control paradigms	1
Wy3	**Turing machines and formal logic** 3.1 Intelligent systems 3.2 The cognitive paradigm 3.3 Essential characteristics of intelligence 3.4 Hierarchy of algorithmic and reflective activities 3.5 Autonomous system model 3.6 Formal logic of the autonomous system 3.7 Sentence calculus 3.7.1 Diadic operations 3.7.2 Unary operations 3.7.3 Truth table 3.7.4 Subsequent concepts in logic 3.8 Algorithms 3.9 Numerical systems 3.10 Turing machine 3.10.1 Logic processing 3.10.2 Machine components 3.10.3 Operation of the machine 3.10.4 Further evolution of the Turing machine 3.10.5 Examples Production of proteins in a cell Polymerase and ribosomes	1
Wy4	**Set calculus** 4.1 Predicate calculus 4.2 1st order logic 4.3 Sharp and fuzzy sets 4.4 Set theory	1
Wy5	**Artificial neural networks** 5.1 Natural and artificial neurons 5.1.1 Biological inspiration 5.1.2 Mathematical description 5.1.3 Linear network 5.1.4 Neural activation functions 5.2 Neural networks 5.2.1 linear 5.2.2 perceptron 5.2.3 Sigmoid 5.2.4 Network with threshold yes/no 5.2.5 Selecting the activation function	1

	5.3 Learning neural networks 5.3.1 Supervised and unsupervised learning 5.3.2 The Hebb Rule 5.3.3 Adaline network 5.3.4 Linear network - teaching a single neuron 5.3.5 Perceptron network - teaching a single neuron 5.3.6 Sigmoid network - learning a single neuron 5.3.7 Sigmoid network - learning neural layers 5.3.8 Delta rule 5.3.9 Method for identifying any object (linear or non-linear) by means of an artificial neural network 5.3.10 Neural reverse model of an object (process) 5.3.11 Neural controller 5.3.12 Widrow-Hoff Rule 5.3.13 Correlation rule 5.4 Self-organising maps of Kohonen 5.5 Recurrent networks: Hopfield and Grossberg 5.6 Neural network applications 5.6.1 Example. Test signals for the identification of NO2 emissions from the OP-650 boiler	
Wy6	**Artificial neural networks**, cntd.	1
Wy7	**Artificial neural networks**, cntd.	1
Wy8	**Fuzzy logic** 6.1 History 6.2 Formalities 6.2.1 Set theory 6.2.2 Set operations 6.2.3 Fuzzy sets 6.2.4 Membership functions 6.2.5 Fuzzy operations 6.2.6 Fuzzy sets of Mamdani and Takagi-Sugeno 6.2.7 Fuzzyfing of inputs, rules base and output sharpening (de-fuzzifing) 6.2.8 Fuzzy controller 6.3 Applications 6.3.1 Ventilation control 6.3.2 Fuzzy control and state controller 6.3.3 The movement of robots 6.3.4 Recognition of feelings 6.3.5 Steam turbine control 6.3.6 From the diary of the cement mill operator... 6.3.7 Train control in Japan 6.3.8 Fuzzy investing in the stock market 6.3.9 Diagnosis of emphysema of the lungs 6.3.10 Prevention of aviation accidents	1
Wy9	**Genetic algorithms and optimisation methods** 7.1 Local and global search 7.2 Numerical optimisation 7.2.1 Newton's method 7.2.2 Gradient method 7.2.3 Gradientless method - based on a network of points in the field of - random search - symplex method (Nelder-Mead) 7.3 Monte Carlo methods 7.4 Simulated annealing 7.5 Genetic algorithms 7.5.1 Characteristics 7.5.2 Evolution 7.5.3 Reproduction 7.5.4 Gene exchange	1

	7.5.5 Mutation 7.5.6 A new generation 7.6 Implementation of a genetic algorithm 7.6.1 Population development process 7.6.2 Creating a new population 7.6.3 Changes in population 7.6.4 Crossing 7.6.5 Mutation 7.6.6 Environmental assessment 7.6.7 Ending evolution 7.6.8 Selection of a new population 7.7 Examples 7.7.1 Control signal 7.7.2 Minimum cost function 7.7.3 Circle and cross 7.7.4 Mouse is looking for cheese 7.7.5 Salesman problem 7.7.6 Minimum of complex function 7.7.7 Minimum of two-dimensional function 7.7.8 Stocks exchange	
Wy10	**Algorithmic methods** 8.1 Introduction 8.2 Artificial life : Boids (birds), Vants (ants), L-systems (plants), Life game 8.3 Machine learning 8.3.1 Feedback and adaptation 8.3.2 Object identification 8.3.3 Selected methods - Unit step, - Dirac's impulse, - Fourier's transformer, - Kuepfmueller, Rotach, Strejc, ARX models	1
Wy11	**Algorithmic methods** , cntd. 8.3.4 Search - Graphs - Bellman's dynamic programming 8.3.5 Entropy of signal 8.3.6 Supervised classification 8.4 Optimisation in control systems 8.4.1 Necessary and sufficient conditions for a minimum in static optimization 8.4.2 Equality constraints 8.4.3 Lagrange multipliers 8.4.4 Dynamic optimisation	1
Wy12	**Immune systems**	1
Wy13	**Convolution networks**	1
Wy14	**Practical neural network recipes**	1
Wy15	**Large language models**	1
Suma godzin		15

laboratory		Number of hours
La1	Neural network in Matlab	1
La2	Cntd.	1
La3	Neural models in Matlab	1
La4	Cntd.	1

La5	Fuzzy logic in Matlab	1
La6	Cntd.	1
La7	Genetic algorithm	1
La8	Cntd.	1
La9	Convolution neural network	1
La10	Cntd.	1
La11	Algoritmic methods. Identification. Dynamic programming.	1
La12	Cntd.	1
La13	Algoritmic methods. State space controllers	1
La14	Cntd.	1
La15	Credit	1
Suma godzin		15

TEACHING TOOLS USED	
N1	Presentations
N2	Computer programming of examples

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P1	7	Classes / sprawiozdania/projekty
P2	7	Tests

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Rita Carter, *The human brain*, Weidenfeld / Nicholson 1998
2	Kevin M. Passino, *Fuzzy Control*
3	Jan Jantzen, *Tutorial On Fuzzy Logic*/Design Of Fuzzy Controllers /Tuning Of Fuzzy PID Controllers
4	Fuzzy Logic Toolbox/Matlab
5	Kaczorek T., *Teoria układów regulacji automatycznej.* Część I., Wydanie czwarte, Wydawnictwa Politechniki Warszawskiej, 1971
6	Michalewicz, Zbigniew, *Genetic Algorithms + Data Structures = Evolution Programs*.
7	Zbigniew Czech, *Analiza algorytmów*, Instytut Informatyki Politechnika Śląska, Materiały dydaktyczne, Gliwice, wrzesień 2004
8	Jakubczyk, Rozdział 4. *Algorytmy grafowe*
9	Żurada, Barski, Jędruch, *Sztuczne sieci neuronowe*, PWN, 1996
10	Goodfellow, Bengio, Courville, *Deep Learning*, PWN, 2018
11	Cichosz, *Systemy uczące się*, WNT 2000, 2007

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

Imię i nazwisko:	Janusz Lichota
E-mail:	Lichota@pwr.edu.pl

Biomass and biofuels in energy production

Faculty of	**Mechanical and Power Engineering**
Name in English	**Biomass and biofuels in energy production**
Name in Polish	**Produkcja energii z biomasy i biopaliw**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2351**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15	15	
Number of hours of total student workload (CNPS)	50		25	25	
Form of crediting	Egzamin		Zaliczenie	Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	2		1	1	
including number of ECTS points for practical (P) classes			1	1	
including number of ECTS points for direct teacher-student contact (BU) classes	1,44		0,76	0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Thermodynamics, combustion and boilers, heat transfer
2.	Environmental protection issues, waste management

SUBJECT OBJECTIVES

C1	Introduction to classification and general characteristics of biomass and biowaste as fuel acquainted with the processes of biomass preparation for energy production. Familiarization with the technologies of energy production from biomass and biofuels.
C2	Development skills of characterizing biofuels for the power energy sector.
C3	Acquisition of skills for biomass boiler balance calculation and evaluation of biomass furnaces.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Describe the general classification of biomass and characterize their fundamental properties and analytical methods for their determination
PEU_W02	Description of the mechanisms of combustion of biomass and list the main systems of combustion and pretreatment of biomass and biowaste
PEU_W03	Identify and characterize the main technologies of biomass co-firing with conventional solid fuels

relating to skills:	
PEU_U01	Identify and characterize the main parameters and processes characterizing biofuels for the power energy sector.
PEU_U02	Perform balance calculations of biomass boiler, with combustion chamber, – depends on type of biomass.

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Wy1-3	State of art for energy production from biomass. The potential of biomass, biomass types, definition of basic physical-chemical properties of biomass; power plant technical limitations resulting from biomass properties. Analytical methods of biomass characterization as a fuel.	6
Wy4-6	Energy fuel production from biomass formed by the mechanical and thermal pretreatment: drying, pelletizing, grinding, torrefaction and pyrolysis, fermentation,	6
Wy7-9	Combustion of biomass. Small, medium and large capacity power units using biomass. Types of furnaces depending on the boiler capacity, co-firing technique - advantages and disadvantages in power boilers. Transport system of biomass and its storage.	6
Wy10-14	The current state of the environment and reasons for searching for new energy sources. Causes and sources of waste generation in technological processes. Polish and EU policy on waste management. Legal, environmental and technological aspects of the use of alternative fuels, solid and liquid bio-waste. Preparation, processing and management of alternative fuels. Circular economy.	10
Wy15	Colloquium.	2
Suma godzin		

	laboratory	Number of hours
La1-5	Characterization of alternative fuels, preparation for testing, sample averaging, grinding. Determining the content of chlorine, mercury and calorific value, classifying fuels in accordance with CEN standards, and determining the share of the biogenic part.	9
La6-8	Analysis of thermal and pretreatment of biomass and utilization under combustion processes: drying , torrefaction, combustion with the flue gas analysis.	6
Suma godzin		15

	project	Number of hours
Pr1-2	Calculation of different type biomass composition with LHV for different moisture content	3
Pr3-4	Balance calculation of biomass combustion in stoichiometric condition.	4
Pr5-6	Thermal balance calculation of selected biomass furnace, calculation of combustion efficiency.	4
Pr7-8	Design of combustion chamber fired with biomass.	4
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture using multimedia presentation
N2	Individual work - self-study and exam preparation
N3	Discussion of laboratory tasks, individual work - preparation for laboratory
N4	Conceptual design and discussion of solutions for calculations.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation	Educational effect number	Way of evaluating educational effect achievement

(F– forming (during semester), C– concluding (at semester end)		
C1	PEU_W01-W03	Colloquium.
F1	PEU_U01	Evaluation of reports. P=(F1+F2+...+Fn)/n
C2	PEU_U02	Evaluation of final project and discussion in the field of biomass technology.

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Rosendahl L., Biomass combustion science, technology and engineering, Woodhead Publishing Limited, 2013
2	Dahlquist E., Technologies for converting biomass to useful energy: combustion, gasification, pyrolysis, torrefaction and fermentation, CRC Press, Taylor & Francis Group, 2013,
3	Jaap K. Van Loo S., The handbook of Biomass Combustion and Co-firing; Earthscan Publications, Taylor & Francis Ltd., 2008
4	Tillman D. A., Wood Combustion, Elsevier, 2012
5	Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies, P. Jayarama Reddy, 2016
6	Waste Incineration Handbook, Paul N. Cheremisinoff, 2013
7	Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines, Dhananjay Kumar, Avinash Kumar Agarwal, 2016
8	Basu P, .Boilers and Burners Design and Theory, Springer New York, 2012
Secondary literature	
1	GE. Klugmann-Radziemska; J. T. Haponiuk; J. G. Datta; K. Formela; M. Sienkiewicz; M. Włoch, Nowoczesne technologie recyklingu materiałowego, Wydawnictwo Politechniki Gdańskiej, Gdańsk 2017.
2	International Energy Agency, https://www.iea.org
3	Bank Danych Lokalnych, https://www.bdl.stat.gov.pl
4	Internetowy System Aktów Prawnych (ISAP), http://prawo.sejm.gov.pl
5	EUR-Lex Baza aktów prawnych Unii Europejskiej, https://eur-lex.europa.eu
6	Confederation of European Waste-to-Energy Plants, http://www.cewep.eu
7	M. Hordyńska, Ekologistyka i zagospodarowanie odpadów, Wydawnictwo Politechniki Śląskiej, Gliwice 2017
8	Kruczek S., Kotły. Konstrukcje i obliczenia, Oficyna Wydawnicza Politechniki Wrocławskiej, 2002
9	R. Wasielewski, B. Tora, Stałe paliwa wtórne, Górnictwo i Geoinżynieria, Rok 33, Zeszyt 4, 2009

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

Imię i nazwisko:	supervisor: PhD Michał Ostrycharczyk teaching team: PhD Arkadiusz Szydełko, PhD Krystian Krochmalny
E-mail:	michal.ostrycharczyk@pwr.edu.pl

CFD simulations of power generation units

Faculty of	**Mechanical and Power Engineering**
Name in English	**CFD simulations of power generation units**
Name in Polish	**Symulacje CFD urządzeń energetycznych**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2340**
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)	50		50		
Form of crediting	Exam		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,44		1,36		

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 simulations
C2	providing knowledge about energetic systems optimizing methods
C3	developing skills of creating mesh for defined geometry and application
C4	developing abilities of performing numerical calculations for simple and complex thermal-flow processes

SUBJECT LEARNING OUTCOMES

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

	Form of classes - 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	Types of boundary conditions and their application.	2
Lec4-6	Finite volume method	6
Lec6	Algorithm for pressure and velocity fields calculations for fluid flow.	2
Lec7	Iteration methods for solving algebraic systems of equations.	2
Lec9	Turbulence. Models of turbulence.	2
Lec10	Types of numerical errors during CFD simulations and their influence on calculations.	2
Lec11-12	Large Eddy Simulation (LES) method.	4
Lec13-14	Optimizing of energy generation installations .	4
Lec15	Examples of energetic systems optimizing.	2
Total hours		30

	laboratory	Number of hours
La1	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
La2-3	Flow through isolated pipeline. Calculating CHT problem, solving for pressure losses. Testing numerical results stability and computational cost against mesh parameters.	8
La4	Results post-processing and visualization. Report generation. Simple scripting in data manipulations.	4
La5-7	CFD calculations and optimization of a heat exchanger.	12
La8-10	CFD calculations and optimization of a pump.	12
La11	CFD calculations of a renewable energy source – wind turbine	4
La12	CFD calculations of a renewable energy source – solar thermal collector	4
La13-15	Individual project	12
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	Office hours

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01- PEU_U05	Report 1
F2	PEU_U01- PEU_U05	Report 2
F3	PEU_U01- PEU_U05	Report 3
F4	PEU_U01- PEU_U05	Report 4
F5	PEU_U01- PEU_U05	Report 5

F6	PEU_U01- PEU_U05	Report 6
P1	PEU_W01- PEU_W08	Exam

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)

Imię i nazwisko:	Sławomir Pietrowicz
E-mail:	slawomir.petrowicz@pwr.edu.pl

Cold chain

Faculty of	**Mechanical and Power Engineering**
Name in English	**Cold chain**
Name in Polish	**Obiekty chłodnicze**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2365**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	25				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	0,68				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Fundamental knowledge of thermodynamics and fluid mechanics.

SUBJECT OBJECTIVES

C1	Familiarize students with the basic knowledge about refrigeration technologies used in the cold chain.
C2	Familiarize students with the mathematical model for cooling and freezing processes.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Student is able to choose the right refrigeration technology depending on the individual requirements of the stored goods
PEU_W02	Student is able to calculate the needed cooling capacity depending of the individual requirements of the stored goods or processes.

PROGRAMME CONTENT

Form of classes - lecture	Number

		of hours
Wy1	Scope of the lecture, credit conditions, literature. Basic thermal processes and their effect on organic materials.	1
Wy2	Cooling processes and characteristics of the most important accompanying processes	2
Wy3	Air cooling environment and the basics of cooling theory	2
Wy4	The theory of food freezing	2
Wy5	Food freezing by using the with air-blowing techniques	2
Wy6	Fluidized bed freezing – mathematical model	2
Wy7	Contact, immersion and crio freezing	2
Wy8	Final test	2
Suma godzin/ Total hours		15

TEACHING TOOLS USED	
N1	Traditional lecture with the use of multimedia presentation
N2	Self-study – reading of supplementary materials.
N3	Office hours.
N4	
N5	

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P1	PEU_W01	Colloquium
P2	PEU_W02	Colloquium

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Stoecker, W.F. and Jones, J.W. 1982. Refrigeration and Air Conditioning, NY, USA. McGraw Hill.
2	Mallett, C.P. 1993. Frozen Food Technology. Chapman and Hall, London, UK
Secondary literaturę	
1	

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

Imię i nazwisko:	Stefan Reszewski
E-mail:	Stefan.reszewski@pwr.edu.pl

Communication in a multicultural environment

Faculty of	**Mechanical and Power Engineering**
Name in English	**Communication in a multicultural environment**
Name in Polish	**Komunikacja w środowisku wielokulturowym**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**ogólnouczelniany**
Subject code	**W08W09-SM1117**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	50				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	0,68				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	No prerequisites

SUBJECT OBJECTIVES

C1	To develop and improve critical and independent thinking skills.
C2	To shape and improve ability to formulate and express thoughts clearly and unambiguously.
C3	Introduction to the basic issues of multicultural communication.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	[P7S_WK]: knows and understands the social conditions of undertaking various types of professional activities relating to the awarded qualification, including regulations on industrial property rights and copyrights.
relating to skills:	
PEU_U01	[P7S_UO]: is able to direct the work of a team and is able to interact with others in teamwork and take a leading role in teams.
relating to social competences:	
PEU_K01	[P7S_KO]: is ready to fulfil one's social obligations, inspire and organise activities on behalf of society and is ready to initiate activities on behalf of the public interest.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction	1
Wy2	Communication process in multicultural environment.	2
Wy3	Formation of social norms in different cultures – examples.	2
Wy4	Stereotypes and myths in selected cultures.	2
Wy5	Communication barriers.	2

Wy6	International work environment.	2
Wy7	Techniques supporting communication.	2
Wy8	New media – problems for research, social challenges.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Lecture supported by audiovisual material
N2	Individual work of students
N3	Group work
N4	Case study
N5	Exercises

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01 PEU_U01 PEU_K01	Colloquium or final speech
F2	PEU_W01 PEU_U01 PEU_K01	Activity in class

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	S. Ting-Toomey, L. Chung, Understanding intercultural communication, University Press, Oxford 2021.
2	Communication in the Real World: An Introduction to Communication Studies, University of Minnesota Libraries Publishing edition, Minnesota 2016.
3	F. Patel, M. Li, P. Sooknanan, Intercultural Communication Building a Global Community, SAGE Publications, London 2011.
4	E. Meyer, The Culture Map: Decoding How People Think, Lead, and Get Things Done Across Cultures, Hachette Book Group USA, 2016.
Secondary literaturę	
1	D. Andrews, Technical communication in the global community, Prentice Hall 2001.
2	Ethical Issues in International Communication, ed. A. G. Nikolaev, Palgrave Macmillan 2011.
3	A. Yüksel Mermod, Corporate Social Responsibility in the Global Business World, Springer 2013.

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

Imię i nazwisko:	dr Teresa Marcinów, dr Rafał Szopa
E-mail:	teresa.marcinow@pwr.edu.pl, rafal.szopa@pwr.edu.pl

Cooling systems

Faculty of	**Mechanical and Power Engineering**
Name in English	**Cooling systems**
Name in Polish	**Systemy chłodnicze**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2360**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	50			50	
Form of crediting	Zaliczenie			Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2	
including number of ECTS points for direct teacher-student contact (BU) classes	1,28			0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Proficiency in fundamental concepts of thermodynamics, fluid mechanics, heat and mass transfer, and technical drawing, demonstrated through successful grade(s).
2.	Proficiency in refrigerants and compression refrigeration systems demonstrated through positive grade(s).
3.	Proficiency in technical drawing validated by positive grade(s).

SUBJECT OBJECTIVES

C1	Introduce students to the regulations and standards governing refrigeration and cooling system design and operation.
C2	Provide students with knowledge about system classification, their functioning, and practical applications.
C3	Familiarize students with safety regulations influencing system selection and operation, including the choice of working fluids.
C4	Develop students' skills in designing cooling and refrigeration systems.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Demonstrates knowledge of rules and standards for designing and operating refrigeration systems and refrigeration facilities.
PEU_W02	Possesses knowledge of industrial, retail, and household refrigeration equipment, including refrigerated transport solutions.
PEU_W03	Exhibits expertise in the cooling of a variety of food products, including meat, vegetables, and beverages.
relating to skills:	

PEU_U01	Can select an appropriate cooling system for specific products or applications.
PEU_U02	Can calculate the required capacity for a refrigeration system, designing the system, and choosing its components.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1-2	Introduction to the lecture. The basic rules and standards for safety and design of cooling systems and refrigeration plants, including the standard EN 378 for refrigerating systems and heat pumps.	4
Wy3-5	Refrigerated facility design. Building considerations and thermal envelope.	6
Wy6-9	Industrial cooling systems (cooling of fruits, vegetables, meat, fish, etc. and other products.)	8
Wy10-11	Household and retail store cooling systems (refrigerators, freezers, vending machines, ice dispensers, etc.)	6
Wy12-14	Refrigerated transport (incl. refrigerated trucks, railway cars, air, and marine cargo)	6
Wy15	Final test.	2
Suma godzin		30

project		Number of hours
Pr1	Organizational aspects, literature and material selection, project content discussion, assignment of individual project topics, and the timeline for completing project phases	2
Pr2-3	Creating a comprehensive technology overview for the developed system tailored to each facility, and crafting implementation guidelines for location-specific refrigeration systems.	4
Pr4-7	Creating construction plans for cold rooms or spaces with cooling equipment, choosing the refrigeration system concept, performing system load calculations, determining refrigeration cycle calculations, designing installation diagrams, selecting system components, developing system-related pipeline designs, creating project drawings (including essential plans and sections), and finalizing the technical description for the proposed system.	8
Pr8	Submission of the complete project report.	1
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture with multimedia presentation.
N2	The project - consultation, discussion, and presentation of the project.
N3	Own work - the project development.
N4	Own work - self-study and preparation for the final test.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P1	PEU_W01-W03	Result of the final test.
P2	PEU_U01-U02	Quality of the project report.

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	2014 ASHRAE® Handbook - Refrigeration (SI Edition) (@Knovel)
2	2017 ASHRAE® Handbook - Fundamentals (SI Edition) (@Knovel)
3	Stoecker, Wilbert F: Industrial refrigeration handbook. New York, McGraw-Hill, 1998.
4	Ibrahim Dinçer: Refrigeration systems and applications. Chichester : John Wiley & Sons, 2003.
5	EN 378:2008+A2:2012 Refrigerating systems and heat pumps – Safety and environmental requirements

Secondary literature	
1	Diverse online resources containing catalogs of refrigeration components and units.
2	EN 1861:1998 Refrigerating systems and heat pumps - System flow diagrams and piping and instrument diagrams - Layout and symbols
3	EN 13136:2013 Refrigerating systems and heat pumps -Pressure relief devices and their associated piping – Method for calculation

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

Imię i nazwisko:	Bartosz Zajączkowski
E-mail:	bartosz.zajaczkowski@pwr.edu.pl

Cryogenic systems and applied sperconductivity

Faculty of	**Mechanical and Power Engineering**
Name in English	**Cryogenic systems and applied sperconductivity**
Name in Polish	**Systemy kriogeniczne i nadprzewodnictwo stosowane**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2366**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	50			30	
Form of crediting	Zaliczenie			Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,28				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge of issues concerning thermodynamics basis of cryogenics and low temperature physics
2.	Knowledge of the basics of heat transfer and fluid mechanics
3.	Knowledge of the basics of electricity and magnetism
4.	Knowledge of the basics of mechanical design
5.	Knowledge on the technical drawing
6.	Ability to use the 2D and 3D CAD software
7.	Ability to work and cooperate in heterogeneous groups

SUBJECT OBJECTIVES

C1	Make students acquainted with components, design and analysis of the cryogenic systems
C2	Providing information about superconductivity phenomenon and its application in industry, energetics, medicine and science
C3	To familiarize students with chosen superconducting materials and with their physical properties
C4	Providing information about superconductors manufacture methods
C5	Providing information about methods of cryo-stabilization of low- and high-temperature superconducting composites
C6	Preparing students for the realization of the projects of cryogenic equipment
C7	Developing the skills in the preparation and presentation of technical documentations

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	possesses a knowledge in superconductivity and its application in industry, energetics, medicine and science
PEU_W02	names and characterizes some chosen low- and high-temperature superconductors
PEU_W03	has knowledge on the superconductors production technologies
PEU_W04	has knowledge on the cryostabilization of high-and low-temperature superconductors
PEU_W05	knowledge the cryogenic systems definition and classification
PEU-W06	knowledge of cryogenic system components, understanding of the particular component role in the system, knowledge of the components sizing procedure as well as selection of the component type
PEU-W07	knowledge of types of instrumentation for measurement and control of process variables in the cryogenic systems
PEU-W08	knowledge and understanding of design rules of basic and complex cryogenic systems with liquid, superfluid and supercritical helium
relating to skills:	
PEU_U01	can design the selected equipment and components of the installation applied in gas and cryogenic technologies in accordance with selected design codes and standards
PEU_U02	can selects the necessary auxiliary equipment and safety devices
PEU_U03	can develop technical design documentations
relating to social competences:	
PEU_K01	is able to active listening
PEU_K02	is able to work in group

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Definition and classification of cryogenic systems and system components	2
Wy2	Cryogenic materials	2
Wy3	Cryogenic system components – part 1	2
Wy4	Cryogenic system components – part 2	2
Wy5	Cryogenic system components – part 3	2
Wy6	Cryogenic Instrumentation – part 1	2
Wy7	Cryogenic Instrumentation – part 2	2
Wy8	Introduction to superconductivity	2
Wy9	Theory of superconductivity	2
Wy10	Energy losses in superconductors	2
Wy11	Superconducting devices design and production –part 1	2
Wy12	Superconducting devices design and production –part 2	2
Wy13	Cryo-stabilization of low-temperature and high-temperature superconductors	2
Wy14	Helium distribution systems for large superconducting devices	2
Wy15	Test	2
Suma godzin		30

project		Number of hours
Pr1	Presentation of project subjects	2
Pr2	Selection of the working fluid type and its consumption for selected device	2
Pr3	Transfer line sizing and modularization, selection of the cryogenic vessel capacity and design pressure	2
Pr4	Design of transfer line module female and male bayonet connections, selection of the process pipe thermal compensation element and determination of the inner support system	2
Pr5	Determination of the heat losses to the process pipe	2
Pr6	Selection of the safety and axillary equipment	2
Pr7	Preparation of the project report, manufacturing drawings and assembly procedure	2
Pr8	Acceptance of the students' projects	1
Suma godzin		15

TEACHING TOOLS USED	
N1	Information lecture
N2	Multimedia presentation
N3	Self-work, self-studies and preparation for the final test
N4	Individual discussion with students and consultancies
N5	Project results presentation

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
Lecture C	PEU_W01 -PEU_W08 PEU_K01	Final test
Project C	PEU_U01- PEU_U03	Project defense

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	A.M. Arkharow, I.V. Marfenina, Ye.I. Mikulin, Cryogenic systems, Bauman Moscow State University Press, Moscow, 2000
2	Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker, USA.2005
3	Chorowski M., Kriogenika, podstawy i zastosowania, IPPU MASTA, Gdańsk 2007
4	J.G. Weisend II, Handbook of Cryogenic Engineering, Taylor&Francis, USA, 1998
5	A.R. Jha, Cryogenic Technology and Applications, Elsevier, USA, 2008
6	W. Buckel, R. Kleiner, Superconductivity: Fundamentals and Applications, Wiley-VCH, 2004
7	P. J. Lee, Engineering Superconductivity, Wiley-IEEE Press; 1 edition, 2001
Secondary literature	
1	R.C. Scurlock, Low-Loss Storage and Handling of Cryogenic Liquids: The Application of Cryogenic Fluid Dynamics, Kryos Publications, United Kingdom, 2006
2	G. Ventura, L. Risegari, The Art of Cryogenics, Elsevier, USA, 2008
3	Advances in Cryogenic Engineering, Transactions of the Cryogenic Engineering Conferences
4	C.P. Poole., H.A. Farach, R.J. Creswick, R. Prozorov, Superconductivity, Academic Press, 2007
5	V.L. Ginzburg, E.A. Andryushin, Superconductivity, World Scientific Publishing Company, 2004

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

Imię i nazwisko:	Jarosław Poliński
E-mail:	jaroslaw.polinski@pwr.edu.pl

Cryogenics

Faculty of	**Mechanical and Power Engineering**
Name in English	**Cryogenics**
Name in Polish	**Kriogenika**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM23564**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30	15	
Number of hours of total student workload (CNPS)	75				
Form of crediting	Exam		Zaliczenie	Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	3		2	1	
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,44				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Advanced knowledge of thermodynamics, heat transfer and fluid mechanics
2.	Basic knowledge of low temperature physics, mechanical and material engineering
3.	Basic knowledge of process simulation software programs

SUBJECT OBJECTIVES

C1	Familiarizing students with cryogenics, cryogenic technologies and applications
C2	Familiarizing students with construction and operation of cryogenic devices and systems
C3	Practical training in safe handling of cryogenic fluids, preparing experiment and solving technical problems
C4	Practical training in measurements of working parameters, data collection and analysis
C5	Practical training in process / system calculations using process simulation software programs

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	understands the risk and hazard of cryogenic temperature/fluids/gases, devices and systems
PEU_W02	knows physics and mathematical background of low temperature processes
PEU_W03	knows the flow diagrams of cryogenic refrigerators and liquefiers
PEU_W04	knows the methods of reaching ultralow temperatures
PEU_W05	knows the phenomena of superfluid helium and superconductivity
relating to skills:	
PEU_U01	is able to calculate an energy balance of cryogenic system

PEU_U02	is able to estimate temperature drop in cooling processes
PEU_U03	is able to describe processes of cryogenic refrigerators and liquefiers
PEU_U04	is able to handle the cryogenic liquids in a safe way
PEU_U05	is able to perform low temperature measurements
PEU-U06	is able to model the cryogenic system in process simulation software
relating to social competences:	
PEU_K01	is able to work and cooperate in heterogeneous groups
PEU_K02	is able to communicate effectively with others in foreign language
PEU_K03	is able to active listening
PEU_K04	is able to leadership the group

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to cryogenics, basic definitions, history Applications of cryogenics and cryogenic technologies	2
Wy2	Introduction to safety engineering in cryogenics	2
Wy3	Gas temperature decrease: process of isentropic expansion	2
Wy4	Gas temperature decrease: process of isenthalpic expansion	2
Wy5	Gas temperature decrease: process of free exhaust	2
Wy6	Cryogenic liquefiers and refrigerators with recuperative heat exchangers – Joule-Thomson, Claude and Brayton systems	2
Wy7	Liquefaction of cryogenic gases, minimal work of liquefaction Thermodynamic optimization of the liquefier stage number	2
Wy8	Gaseous cryogenic refrigerators with regenerative heat exchangers – Stirling, Gifford-McMahon, pulse tubes	2
Wy9	Gaseous cryogenic refrigerators with regenerative heat exchangers – Vuilleumier-Taconis Categorization of cryogenic liquefiers and refrigerators	2
Wy10	Temperature decrease in process of adiabatic demagnetization, magnetic refrigerators	2
Wy11	Basic properties of superfluid helium He II	2
Wy12	Superfluid helium technologies	2
Wy13	Methods of obtaining the temperatures below 1, sorption refrigerators	2
Wy14	Dilution of 3He in 4He II and solidification of 3He, dilution and Pomeranchuk refrigerators	2
Wy15	New applications of cryogenics, laser cooling	2
Suma godzin		30

laboratory		Number of hours
La1	Introduction to cryogenic laboratory, physical properties of cryogenic liquids	2
La2-3	Safety engineering in cryogenics – problem of Oxygen Deficiency Hazard, risk of storage tank failures	4
La4-5	Heat transfer at cryogenic temperatures, cryogenic thermal insulations	4
La6-7	Cryogenic liquefiers and coolers with recuperative heat exchanger – Joule-Thomson systems	4
La8-9	Cryogenic refrigerator with regenerative heat exchanger – Gifford McMahon system	4
La10-11	Determination of the critical current for HTS superconducting tapes at different temperature levels and different magnetic field levels	4
La12-13	Modelling / measurements of temperature propagation in material	4
La14	Measurements of the gas re-gasification heat exchanger	2
La15	Additional /extra laboratory, final grading	2
Suma godzin		30

project		Number of hours
Pr1	Presentation of project subjects	1
Pr2	Introduction to process simulation software programs	2
Pr3	Modelling of basic thermodynamic processes, selection of working fluid, equation of state	2
Pr4	Modelling of pressure devices, compressors, expanders, valves	2
Pr5	Modelling of heat exchangers parameters	2
Pr6	Auxiliary modules, logical blocks, indicators	2
Pr7	Modelling of complex cryogenic system 1	2
Pr8	Modelling of complex cryogenic system 2	2
Pr9	Acceptance of the students' projects	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture with multimedia presentations
N2	Software and simulators supporting process calculations
N3	Laboratory experiments aimed at process identification and parameters measurements
N4	Individual consultancies
N5	Student individual work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
Lecture C	PEU_W01 -PEU_W05 PEU_K03	Final exam
Laboratory F C	PEU_U01 -PEU_U05 PEU_K01-PEU_K04	Written reports Average grade from the report's grades
Project C	PEU_U01 -PEU_U06 PEU_K01-PEU_K04	Submission of project technical documentation Project presentation and defence

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	A. Arkharov, I. Marfenina, Ye. Mikulin, Cryogenic Systems, Bauman Moscow, State Technical University Press, 2000
2	Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker, USA.2005
3	Chorowski M., Kriogenika, podstawy i zastosowania, IPPU MASTA, Gdańsk 2007
4	A.Piotrowska-Hajnus, J.Fydrych, J.Poliński, Cryogenic Engineering Laboratory Handbook, Wroclaw University of Technology 2010
5	S. Mokhatab at. al., Handbook of Liquefied Natural Gas, Elsevier Inc., 2014, ISBN 978-0-12-404585-9
Secondary literature	
1	R.C. Scurlock, Low-Loss Storage and Handling of Cryogenic Liquids: The Application of Cryogenic Fluid Dynamics, Kryos Publications, United Kingdom, 2006
2	G. Ventura, L. Risegari, The Art of Cryogenics, Elsevier, USA, 2008
3	Advances in Cryogenic Engineering, Transactions of the Cryogenic Engineering Conferences
4	W. Buckel, R. Kleiner, Superconductivity: Fundamentals and Applications, Wiley-VCH, 2004

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

Imię i nazwisko:	Jarosław Poliński
E-mail:	jaroslaw.polinski@pwr.edu.pl

Finite element analysis

Faculty of	**Mechanical and Power Engineering**
Name in English	**Finite element analysis**
Name in Polish	**Metoda elementów skończonych**
Main field of study	**Power Engineering**
Specialization	**Computer Aided Mechanical and Power Engineering; Renewable Sources of Energy; Refrigeration and Cryogenics**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Language	**English**
Education cycle from	**2023/2024**
Subject code	**W09ENG-SM2339**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Examination		Crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes	3		2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,5		1,5		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic knowledge and skills in the field of: mechanics, thermodynamics, basics of machine construction, strength of materials, basics of materials science
2.	Solid models preparation in any CAD-software

SUBJECT OBJECTIVES

C1	To acquaint students with the knowledge of the theory of the finite element method.
C2	To develop students skills to build an appropriate model for FEA simulations with one-, two- and three-dimensional models.
C3	To develop students skills for numerical modeling of real objects and phenomena.
C4	The acquisition of skills by students to critically analyze the results of the FEA.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge of the theory of the finite element method
PEU_W02	Has knowledge of the preparation and formulation of numerical models for FEA calculations
PEU_W03	Has knowledge about the limitations and possibilities of using FEM analysis for numerical verification of the operating conditions of individual elements and structural systems

relating to skills:	
PEU_U01	The acquisition of skills by students to use the FEM-based algorithm software to perform numerical calculations
PEU_U02	Can define and apply the appropriate type of numerical model in based on FEM and depending on the problem being solved
PEU_U03	Can perform a critical analysis of the obtained results from FEA calculations
relating to social competences:	
PEU_K01	Acquires the ability to take responsibility for the own work
PEU_K02	To develop of thinking and acting creatively

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Wy1	Introduction to mathematical modeling and numerical engineering analysis. Examples of FEA.	2
Wy2	Fundamentals of the finite element method.	2
Wy3	Methodology of FEM model formulation.	2
Wy4	Types and characteristics of finite elements.	2
Wy5	Shape function in the description of the finite element structure.	2
Wy6	FEM model assumptions - presentation of basic relationships for one-dimensional (1D) models.	2
Wy7	Examples of the application of the FEM algorithm in numerical strength of materials calculations.	2
Wy8	FEA strength of materials calculations for one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) model - comparative analysis.	2
Wy9	Nonlinearity in FEM calculations. Isotropic and anisotropic properties of materials and their influence on the construction of a discrete model.	2
Wy10	Dynamic analysis using the FEM algorithm. Modal analysis.	2
Wy11	FEM analysis of steady state heat flow processes.	2
Wy12	The influence of changes of boundary conditions on the obtained solutions of selected engineering problems.	2
Wy13	FEM analysis of structural elements under complex load state.	2
Wy14	Analysis of factors and evaluation of their influence on the accuracy of FEA simulation and obtained results.	2
Wy15	Implementation of the FEA algorithm in computer softwares for solving engineering problems.	2
Total hours		30

	laboratory	Number of hours
La1	Presentation of the program of laboratory. Methodology of preparation and perform of numerical analysis.	2
La2	Introduction to the FEA simulation software. Principles of geometrical models preparation.	2
La3	Principles of numerical models preparation - discretization and boundary conditions.	2
La4	Definition and implementation of material properties. Analysis of selected factors in FEA-algorithm and evaluation of their influence on the accuracy of calculations.	2
La5	Definition and range of applicability of solid models. Solid models of isotropic materials - strength of materials analysis of machine elements in steady state conditions.	2
La6	Definition and range of applicability of beam model. The use of beam models in the analysis of frame structures.	2
La7	Definition and range of applicability of shell model. The use of shell models in the analysis of the operating conditions of frame structures.	2
La8	2D models in strength of materials numerical analysis. Plane stress, plane strain and axisymmetric models.	2
La9	Shell models of pressure apparatus equipment and elements.	2
La10	Isotropic and anisotropic properties of materials and their influence on results of numerical strength of materials analysis.	2
La11	Modal analysis - vibration characteristics (natural frequencies and mode shapes).	2

La12	FEM analysis of steady state heat flow processes.	2
La13	Strength of materials analysis in complex mechanical structures using contact dependencies.	2
La14	Feasibility and optimization analysis of solutions within the given criteria.	2
La15	Report of FEA numerical simulations - Results analysis.	2
Total hours		30

TEACHING TOOLS USED	
N1	Traditional lecture with the use of multimedia presentation, blackboard and chalk. Discussion of the problem.
N2	Preparation and presentation of the project and discussion of the obtained solutions and results.
N3	Individual work - models preparation for numerical simulations.
N4	Individual consultations.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01, PEU_W02, PEU_W03, PEU_K02	Final exam
C2	PEU_U01, PEU_U02, PEU_U03, PEU_K01	Work evaluation during the laboratory Preparation of reports based on the conducted numerical analysis

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Zienkiewicz O. C., Taylor R. L., Zhu J.Z., The Finite Element Method: Its Basis and Fundamentals, 7th ed., McGraw-Hill / Butterworth-Heinemann (Imprint of Elsevier), 2013
2	Reddy J. N., An introduction to the Finite Element Method, 3rd ed., McGraw Hill, New York, 2006
3	Bathe K. J., Finite Element Procedures, 2nd ed., K. J. Bathe, Watertown, MA, 2014
4	Thompson M. K., Thompson J. M., Ansys Mechanical APDL for Finite Element Analysis, Butterwoth-Heinemann (Imprint of Elsevier), 2017
5	Alawadhi E. M., Finite element simulations using ANSYS, CRC Press Inc. Taylor & Francis Group, 2019
Secondary literature	
1	Larson M. G., Bengzon F., The Finite Element Method: Theory, Implementation, and Applications, Springer Heidelberg, 2010
2	Madenci E., Guven I., The Finite Element Method and Applications in Engineering Using ANSYS, Springer New York, Second Edition, 2015
3	Chen X., Liu Y., Finite element modeling and simulation with ANSYS Workbench, CRC Press Inc. Taylor & Francis Group, 2018

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

Imię i nazwisko:	Konrad Babul
E-mail:	konrad.babul@pwr.edu.pl

Fuel cells and hydrogen production

Faculty of	**Mechanical and Power Engineering**
Name in English	**Fuel cells and hydrogen production**
Name in Polish	**Ogniwa paliwowe i produkcja wodoru**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2353**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		25		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	1,28		0,76		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge and skills in chemistry, elekctrochemistry, physics, thermodynamics.

SUBJECT OBJECTIVES

C1	Introduction to the principle of fuel cell operation - the basics of electrochemistry .
C2	To become familiar with the classification and general characteristics of fuel cells and to design solutions, general construction and operation of fuel cells and to familiarize with the purpose of different types of fuel cells.
C3	Acquaintance with current hydrogen production and storage technologies and hydrogen characteristics.
C4	Acquainting with development directions of fuel cells in transport application and with energy production systems integrated with fuel cells.
C5	Developing skills to determine fuel cell efficiency and hydrogen production by electrolysis.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	The general classification of fuel cells and their purpose.
PEU_W02	Explanation of the operation of the PEM hydrogen cell.
PEU_W03	Explanation of the operation of other kinds of fuel cells, define the basic parameters characterizing their work.
PEU_W04	Knowledge of the application of fuel cells.
PEU_W05	Characterization and description hydrogen production and storage technologies.

relating to skills:	
PEU_U01	Perform basic measurements of current, voltage and power of fuel cells and electrolyzers.
PEU_U02	Use known measurement techniques to calculate cell efficiency and hydrogen production efficiency.
relating to social competences:	
PEU_K01	

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Wy1	Hydrogen as an energy carrier. Review of current hydrogen applications, assessment of its physical and chemical properties. Safety rules for working with hydrogen.	2
Wy2	Hydrogen production methods - discussion of the main methods used on an industrial scale from raw natural fuels.	2
Wy3	Biological production of hydrogen, photosynthesis ,hydrogen production by digestion processes.	2
Wy4	Hydrogen storage - technology review.	2
Wy5	Hydrogen Fuel Cells – Basic principles. History of fuel cell formation.	2
Wy6	Basics of electrochemistry. Redox reactions and their role in the processes taking place in electrolysers and fuel cells.	2
Wy7	Galvanic cells and batteries. Comparison of primary and secondary cells.	2
Wy8	Classification of fuel cells.	2
Wy9	Proton Exchange Membrane and Direct Methanol Fuel Cell- as low temperature kind of fuel cells.	2
Wy10	Alkaline Fuel Cells, Phosphoric Acid Fuel Cells.	2
Wy11	Less known fuel cells: Direct Carbon Fuel Cells, Phosforic Acid Fuel Cells.	2
Wy12	High temperature fuel cells:Molten Carbonate Fuel Cells, Solid Oxide Fuel Cell.	2
Wy13	Application of fuel cells for automotive, robotics and power engineering.	2
Wy14	Fuel Cell Systems Analyzed.	2
Wy15	Colloquium.	2
Suma godzin		30

	laboratory	Number of hours
La1	Organizational classes - form of assessment, safety rules in the laboratory.	1
La2	Electrolysis of aqueous alkaline and salt solutions.	4
La3	Hydrogen production in the PEM electrolysis process (with proton exchange membrane).	3
La4	Fuel cell system performance testing.	3
La5	Determination of the efficiency of a methanol cell.	2
La6	Determination of the efficiency of hydrogen production in a system powered by renewable energy, with a fuel cell.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Lecture: - traditional lecture using multimedia presentation. - own work - independent studies and preparation for the exam.
N2	Exercises at research positions; - short written tests; - own work - preparation for laboratory exercises and test reports.
N3	Consultations.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01-PEU_W05	Colloquium.
F2	PEU_U01-PEU_U02	Average of grades from reports and tests.

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	C. Spiegel, "Designing and Building Fuel Cells", McGraw-Hill, 2007
2	S.A. Sherif , D. Yogi Goswami , Elias K. Stefanakos , Aldo Steinfeld, Handbook of Hydrogen Energy,2014
Secondary literaturę	
1	M. A. Energii, "The future of hydrogen", 2019
2	"The Hydrogen Economy: A Non-Technical Review", United Nations Environment Program E, 2006.

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

Imię i nazwisko:	dr inż. Monika Tkaczuk
E-mail:	monika.tkaczuk@pwr.edu.pl

Fundamentals of programming

Faculty of	**Mechanical and Power Engineering**
Name in English	**Fundamentals of programming**
Name in Polish	**Podstawy programowania**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2344**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	25		50		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge of calculus
2.	Knowledge of algebra
3.	Knowledge of information technology

SUBJECT OBJECTIVES

C1	Presenting a selected programming environment and showing how to use it in order to obtain a numerical code implementing selected calculation algorithms.
C2	Presentation of sample algorithms implementing selected calculation goals met typically while using mathematical tools in engineer practice, especially during numerical modelling of physical phenomena, such as heat flow or fluid flow.
C3	Developing practical skills leading from identifying a computational problem through selection of algorithms and programming tools, creating code, running the program, up to verifying the correctness and accuracy of the numerical results obtained.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	understands how the computer performs numerical calculations and knows principles of numerical programming
PEU_W02	knows the basic algorithms that solve typical computational tasks occurring when mathematical tools are applied to engineering problems
relating to skills:	

PEU_U01	knows how to use a selected developer environment
PEU_U02	can decide whether a given computational problem can be solved by computer
PEU_U03	is able to select the appropriate numerical algorithm as well as programming tools suitable for coding this algorithm
PEU_U04	subsequently, is able to run correctly and efficiently the code and obtain the desired numerical results

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Introduction. Operating systems, programs, programming languages.	1
Lec2	Program flow control. Calculations using integer and real numbers.	2
Lec3	Loops and logical conditions applied to calculating series, derivatives and integrals.	2
Lec4	File operations. Output and graphic presentation of results.	2
Lec5	Functions and procedures.	2
Lec6	One-dimensional steady heat flow. Internal heat sources.	2
Lec7	Accurate solutions of linear equation systems.	2
Lec8	Written test.	2
Total hours		15

laboratory		Number of hours
La1	Installation of a programming environment. Compilation of a simple program.	2
La2	Calculations with integers and reals. Ranges of values, precision, text formats of real numbers.	2
La3	Calculating series, derivatives and integrals.	2
La4	Functions and procedures.	2
La5	Implementation of numerical algorithms for ordinary differential equations.	2
La6	File operations. Output of results. Graphical presentation of results.	2
La7	One-dimensional heat flow. Internal heat sources.	4
La8	Accurate solution of linear equation systems. Cramer patterns. Gauss elimination. Thomas' algorithm.	4
La9	Relaxation methods for solving systems of linear equations. Jacobi method. Gauss-Seidel method.	2
La10	Numerical solution for selected two-dimensional fluid flows.	8
Total hours		30

TEACHING TOOLS USED	
N1	Lecture using multimedia (presentation - slides), supported by numerical software.
N2	Computer laboratory using programmer's environment for creating numerical programs.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01- PEU_U02	Laboratory reports
P1	PEU_W01- PEU_W02	Written test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	T. Beu: Introduction to Numerical Programming, CRC Press, 2015.
2	D. Yevick: A Short Course in Computational Science and Engineering - C ++ , Java and Octave Numerical Programming with Free Software Tools.
3	W. Cheney, D. Kincaid: Numerical Mathematics and Computing, Thomson Brooks 2008.

4	G. Dahlquist, A. Bjorck: Numerical Methods in Scientific Computing, SIAM 2007.
Secondary literature	
1	D. Haskins: C Programming in Linux.
2	P. Wellin: Programming with Mathematica.

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

Imię i nazwisko:	Józef Rak
E-mail:	jozef.rak@pwr.edu.pl

Geothermal power engineering

Faculty of	**Mechanical and Power Engineering**
Name in English	**Geothermal power engineering**
Name in Polish	**Energetyka geotermalna**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2356**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	25	25			
Form of crediting	Crediting with grade	Crediting with grade			
For group of courses mark final course with (X)					
Number of ECTS points	1	1			
including number of ECTS points for practical (P) classes		1			
including number of ECTS points for direct teacher-student contact (BU) classes	0,68	0,68			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic knowledge in the field of chemistry, physics and thermodynamics.
2.	Basic knowledge related to the construction and operation of power plants.

SUBJECT OBJECTIVES

C1	Acquisition knowledge, taking into account aspects of its application, in the field of: ▪ nature, classification and exploration of geothermal resources, ▪ geothermal energy utilization.
C2	Development of ability to identify and solve practical problems and issues related to the geothermal power.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge related to the exploration, development and utilization of geothermal resources.
PEU_W02	Has knowledge regarding geothermal district heating and power generating systems.
relating to skills:	
PEU_U01	Has ability to apply an integrated knowledge to solving practical tasks in geothermal energy exploration, development and utilization.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec 1	The scope and course completion conditions. Introduction to geothermal energy. History and development of geothermal energy.	1
Lec 2	Structure of the Earth. Mechanism for geothermal heat flow.	2
Lec 3	Model of geothermal system. Classification of geothermal resources.	2
Lec 4	Strategies and techniques in geothermal energy exploration.	2
Lec 5	Geothermal well drilling.	2
Lec 6	Geothermal energy utilization. Direct use of geothermal energy.	2
Lec 7	Indirect use of geothermal energy. Geothermal power generating systems.	2
Lec 8	Colloquium.	2
Total hours		15

classes		Number of hours
Cl 1,2	Solving practical tasks related to the exploration and development of geothermal resources.	3
Cl 3	Solving practical tasks related to the exploitation of geothermal district heating systems.	2
Cl 4,5	Solving practical tasks related to the exploitation of dry steam geothermal power plants.	4
Cl 6,7	Solving practical tasks related to the exploitation of single-flash geothermal power plants.	4
Cl 8	Colloquium.	2
Total hours		15

TEACHING TOOLS USED	
N1	Multimedia presentation.
N2	Solving practical task and results discussion.
N3	Consultations.
N4	Student's own work – preparation for colloquium.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C	PEU_W01 ÷ PEU_W02	Colloquium
C	PEU_U01	Colloquium

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Harsh G., Sukanta R., Geothermal energy: an alternative resource for the 21st century, 2007
2	DiPippo R., Geothermal power plants: principles, applications, case studies and environmental impact, 2008
3	Glassley W., Geothermal Energy: Renewable Energy and the Environment, 2010
4	Pierce V., Introduction to Geothermal Power, 2011
5	Wachtel A., Geothermal Energy, 2010
Secondary literature	
1	Quaschning V., Renewable Energy and Climate Change, 2010
2	Tabak J., Solar and Geothermal Energy, 2009

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

Name and surname:	Wojciech Zacharczuk
E-mail address:	wojciech.zacharczuk@pwr.edu.pl

Heat pumps

Faculty of	**Mechanical and Power Engineering**
Name in English	**Heat pumps**
Name in Polish	**Pompy ciepła**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2358**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	25			25	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark final course with (X)					
Number of ECTS points	1			1	
including number of ECTS points for practical (P) classes				1	
including number of ECTS points for direct teacher-student contact (BU) classes	0,68			0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Technical Thermodynamics
2.	Fluid Mechanics.

SUBJECT OBJECTIVES

C1	Teaching of practical knowledge, regarding heat pump technology, their design and application.
C2	Teaching of skills how to design and analyze heat pumps, their behavior and consequences of its cooperation with various heat sources.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge of rules and standards for design and operation of heat pumps
PEU_W02	Knows the classification of heat pump system
relating to skills:	
PEU_U01	Can choose the proper cycle for a given heat pump system
PEU_U02	Can calculate the capacity of the heat pump system and can design a heat pump system

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Overview of the lecture. Introduction. Principle of operation of the heat pump. Historical overview. Classification and application.	2
Lec2 – Lec7	Heat pumps thermodynamics basis, reversible Carnot Cycle. Heat pump cycle implementing methods. The ideal, comparative and real cycle. Low temperature heat sources: natural, artificial, waste heat. Guidelines for the design of heat exchanger. Ground, water, solar radiation and air as a low temperature heat source. Horizontal, vertical and spiral heat exchangers. Heat transfer coefficients. Thermal and operational parameters. Waste heat as the low temperature heat source. Usefulness assessment of low-temperature heat sources. Refrigerants and coolants. Special features, properties, classification, application possibilities. Heat pump in the heating and DHW system. Hydraulic installations and accumulation tanks. Heat pumps development trends. Ways of meeting energy needs with heat pumps in the context of climate change.	12
Lec8	Colloquium	1
Total hours		15

project		Number of hours
Pr1	Overview and introduction to the project. Distribution of the individual data for the project.	2
Pr2	Calculation of the heat pump cycle. Refrigerant selection. logP-h diagram description. Description of the necessary computer software.	2
Pr3 – Pr7	Calculation of the heat exchangers, selection of the compressor, selection of additional components, individual consultations.	10
Pr8	Submission of completed projects.	1
Total hours		15

TEACHING TOOLS USED	
N1	Traditional lecture with presentation of slides
N2	Self-study – reading of supplementary materials
N3	Self-study – working on the individual project
N4	Self-study – study and preparation to the colloquium.
N5	Consultation – improvement of knowledge

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01 – PEU_W02	Mark of the colloquium
C2	PEU_U01 – PEU_U02	Mark of submitted project

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	2017 ASHRAE Handbook - Fundamentals (SI Edition), © 2009 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
2	2016 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning Applications (SI Edition), © 2016 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
3	Refrigeration, Air Conditioning and Heat Pumps (5th Edition), BOOK•ByHundy, G. F.; Trott, A. R.; Welch, T. C.(2016)
Secondary literature	
1	McQuay International, Geothermal heat pump – Design Manual
2	RETScreen Int. Training Material, Ground Source Heat Pump Project Analysis – Textbook
3	International Renewable Energy Agency. (2013). Heat Pumps - Technology Brief. International Renewable Energy Agency, IRENA

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

Name and surname:	Bogusław Białko
E-mail address:	boguslaw.bialko@pwr.edu.pl

Integrated production systems

Faculty of	**Mechanical and Power Engineering**
Name in English	**Integrated production systems**
Name in Polish	**Zintegrowane systemy produkcji**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**wybieralny**
Subject code	**W09ENG-SM2347**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	25		50		
Form of crediting	Credit		Credit		
For group of courses mark final course with (X)					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	0.68		1.36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge of basic issues related to manufacturing processes.
2.	Ability to use the CATIA system in the generation of parametric models and assemblies.
3.	Knowledge of the basics of machine construction, strength and technical drawing

SUBJECT OBJECTIVES

C1	To familiarize students with CIM (Computer Integrated Manufacturing) - integrated manufacturing environment.
C2	To familiarize students with the development directions of technologies such as: CAD, CFD, MES, CAM, CAPP, MRP, ERP.
C3	Presentation of so-called methods Rapid Prototyping and the so-called Reverse Engineering.
C4	To develop the skills to integrate of the engineering activities into one CAD/CAM system

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Knows the basic production processes and the principles of their integration within the enterprise IT platform.
PEU_W02	Has basic knowledge of CAD, CAE, CAPP, CAM.
PEU_W03	Knows the methods of rapid prototyping and reverse engineering.
relating to skills:	

PEU_U01	Is able to elaborate a complete machine part design in one integrated CATIA package from the concept stage to simulation of the manufacturing process using MES and CAM.
PEU_U02	Is able to use online knowledge resources to select and obtain models of machine parts and is able to prepare a coherent presentation regarding the implemented project.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to classes. The essence of CIM.	2
Wy2	Overview of manufacturing techniques.	2
Wy3	Introduction to CAD.	2
Wy4	Introduction to FEM	2
Wy5	Introduction to CFD.	2
Wy6	Introduction to CAM and CNC.	2
Wy7	Rapid prototyping. Reverse engineering	2
Wy8	Credit	1
Total hours		15

laboratory		Number of hours
La1	Organizational matters. The issue of topics.	2
La2	Conducting of the necessary calculations. Development of the necessary calculation sheets.	2
La3	Conducting of the necessary calculations. Development of the necessary calculation sheets.	2
La4	Conducting of the necessary calculations. Development of the necessary calculation sheets.	2
La5	Conducting of the necessary parametric models in the CATIA system and their integration with calculation sheets.	2
La6	Conducting of the necessary parametric models in the CATIA system and their integration with calculation sheets.	2
La7	Conducting of the necessary parametric models in the CATIA system and their integration with calculation sheets.	2
La8	Conducting of the necessary FEM calculations in the CATIA system and optimization of designed parts.	2
La9	Conducting of the necessary FEM calculations in the CATIA system and optimization of designed parts.	2
La10	Conducting of the necessary FEM calculations in the CATIA system and optimization of designed parts.	2
La11	Preparation of the technical drawings in the CATIA system.	2
La12	Preparation of the technical drawings in the CATIA system.	2
La13	Elaboration of the manufacturing process of the selected part and familiarization with the CATIA CAM module.	2
La14	Elaboration of the manufacturing process of the selected part and familiarization with the CATIA CAM module.	2
La15	Presentation of results and defense of the project	2
Total hours		30

TEACHING TOOLS USED	
N1	Informative lecture using multimedia technologies.
N2	Lecture using blackboard
N3	Consultations
N4	Own work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01	Final test
F2	PEU_W02	Final test
F3	PEU_W03	Final test
F4	PEU_U01	Presentation of results and defense of the project
F5	PEU_U02	Presentation of results and defense of the project

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Dorf R. „Handbook of Design, Manufacturing and Automation", John Wiley & Sons, Inc., Toronto 1994
2	Khan W. Raouf A. „Standards for Engineering Design and Manufacturing", Taylor & Francis Group, LLC, London 2006
3	Saaksvuori A., Immonen A. „Product Lifecycle Management", Springer, Berlin, 2008.
4	Xun Xu „Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations", IGI Global New York 2009.
5	Wu B. „Handbook of Manufacturing and Supply Systems Design", Taylor&Francic, London 2002.
6	Dorf R. „Handbook of Design, Manufacturing and Automation", John Wiley & Sons, Inc., Toronto 1994
Secondary literaturę	
1	Leondes C. „Computer-Aided Design, Engineering, and Manufacturing Systems Techniques And Applications VOLUME 2. Computer Integrated Manufacturing", CRC Press LLC, New York 2001.
2	Leondes C. „Computer-Aided Design, Engineering, and Manufacturing Systems Techniques And Applications VOLUME 5. The Design of Manufacturing Systems", CRC Press LLC, New York 2001.
3	Leondes C. „Computer-Aided Design, Engineering, and Manufacturing Systems Techniques And Applications VOLUME 6. Manufacturing Systems Processes", CRC Press LLC, New York 2001.
4	Leondes C. „Computer Aided and Integrated Manufacturing Systems. Volume 2. Intelligent Systems Technologies", World Scientific Publishing Co. Pte. Ltd. , Singapure 2003.

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

Imię i nazwisko:	Janusz Skrzypacz
E-mail:	janusz.skrzypacz@pwr.edu.pl

Low-temperature technologies

Faculty of	**Mechanical and Power Engineering**
Name in English	**Low-temperature technologies**
Name in Polish	**Technologie chłodnicze**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2338**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50				
Form of crediting	Egzamin		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,44				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic knowledge of thermodynamics and low temperature physics
2.	Basic knowledge of fluid mechanics and heat transfer

SUBJECT OBJECTIVES

C1	Familiarizing the students with thermodynamic fundamentals of refrigeration and cryogenics
C2	Familiarizing the students with low temperature technologies in power engineering and energy storage
C3	Familiarizing the students with construction and operation principals of refrigeration and cryogenic devices
C4	Training in calculations of refrigeration and cryogenic cycles

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	knows the definitions, terminology and applications of refrigeration and cryogenics
PEU_W02	knows physics of low temperature processes
PEU_W03	knows processes of the vapor compression, sorption and cryogenic cycles
PEU_W04	knows refrigeration and cryogenic devices, systems and technologies
PEU_W05	knows basics of the magnetic cooling and space technologies
PEU_W06	knows gas mixture separation methods
relating to skills:	
PEU_U01	is able to calculate refrigeration and cryogenic cycles
PEU_U02	Is able to model simple refrigeration / cryogenic system in DWSIM simulator

relating to social competences:	
PEU_K01	is able to work and cooperate in groups
PEU_K02	is able to communicate effectively with others in foreign language

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to refrigeration and cryogenics	2
Wy2	Thermodynamic backgrounds of low temperature technologies	2
Wy3	Entropy in low temperature cycles. Unavailability of absolute zero	2
Wy4	Introduction to refrigeration technologies - vapor compression cycles	2
Wy5	Sorption technologies in refrigeration and air conditioning	2
Wy6	Refrigeration technologies in power generation and conversion - trigeneration	2
Wy7	Processes used in cryogenics	2
Wy8	Liquefiers and refrigerators with recuperative heat exchangers	2
Wy9	Liquefiers and refrigerators with regenerators	2
Wy10	Liquid Natural Gas (LNG) technologies and applications	2
Wy11	Hydrogen technologies in energy storage and conversion processes	2
Wy12	Introduction to applied superconductivity and cooling systems	2
Wy13	Magnetic cooling in refrigeration and cryogenics	2
Wy14	Cryogenic gas separation, applications in power generation	2
Wy15	Novel technologies in cryogenics, cryogenics in space engineering	2
Suma godzin		30

classes		Number of hours
Cw1	Introduction to tutorial classes, thermodynamic laws in low temperature systems	1
Cw2	Refrigeration cycles 1	2
Cw3	Refrigeration cycles 2	2
Cw4	Introduction to DWSIM simulator, modelling of simple refrigeration system	2
Cw5	Cryogenic cycles 1	2
Cw6	Cryogenic cycles 2	2
Cw7	Modelling of simple cryogenic system (using DWSIM simulator)	2
Cw8	Written test	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture / tutorial classes, presentations available for students
N2	Consultations during office hours
N3	Self-study

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
Lecture C	PEU_W01 - PEU_W06	Examination, written and oral
Tutorial classes C	PEU_U01 – PEU_U02	Test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	A. Arkharov, I. Marfenina, Ye. Mikulin, Cryogenic Systems, Bauman Moscow, State Technical University Press, 2000
2	G/F. Hundy, Refrigeration, Air-Conditioning and Heat Pumps, Butterworth-Heinemann, 2016
3	Presentations (lecture and tutorial)
Secondary literature	
1	J. G. Weisend II, The Handbook of Cryogenic Engineering, Taylor & Francis,1998
2	M.I. Anand, Basics of Refrigeration and Air-Conditioning, ABPL, Second Edition, 2013

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

Imię i nazwisko:	Prof. dr hab. inż. Maciej Chorowski
E-mail:	maciej.chorowski@pwr.edu.pl

Master seminar CAE

Faculty of	**Mechanical and Power Engineering**
Name in English	**Master seminar CAE**
Name in Polish	**Seminarium dyplomowe**
Main field of study	**Power Engineering**
Specialization	**Computer Aided Mechanical and Power Engineering**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional**
Subject code	**W09ENG-SM2350**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					50
Form of crediting					Zaliczenie
For group of courses mark final course with (X)					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					2
including number of ECTS points for direct teacher-student contact (BU) classes					1,28

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Passing all subjects covered by the plan of study in semesters prior to graduation semester ("Diploma seminar" course is accompanied by the "Master of Science Diploma Dissertation" course).

SUBJECT OBJECTIVES

C1	Improving skills in the search for selective knowledge needed to create their own original ideas and solutions, and prepare a presentation that allows pass them on to others meaningful way
C2	Improving the ability to lead creative discussion during which can be justify the proposed solutions or ideas in a concrete and innovations
C3	Improving skills in the dissertation writing on a specific topic, presenting their own achievements against the background of known existing solutions
C4	Shaping the beliefs about the need for permanent development of their personality in all its aspects
C5	Developing a sense of conscientiousness and responsibility for the undertaken commitments, both to themselves and to others

SUBJECT LEARNING OUTCOMES

relating to skills:	
PEU_U01	Student can obtain information from a various sources necessary to comply energy systems projects in order to improve existing solutions
PEU_U02	Student can prepare a coherent paper or presentation on the work carried out, containing the results of the proposed design solutions, technological or operational

PEU_U03	Student is able to objectively justify the desirability of his/her original ideas and solutions during the discussion and critically evaluate the technical solutions proposed by others
relating to social competences:	
PEU_K01	Student understands the need to improve their professional and personal competence, is aware of the social consequences of engineering activities
PEU_K02	Student is able to cooperate and actually behave in a group, actively participate in the discussions on the professional topics with cultural expression and respect for different views of other participants in the discussion
PEU_K03	Student can think and act in a creative and enterprising manner, is able to define the priorities which determine the success of a scheduled task

PROGRAMME CONTENT

seminar		Number of hours
Se1	Discussion of the substantive requirements of the diploma thesis, structure and scope the different types of dissertations. Presentation of the general principles of conduct the final exam. Set a schedule of the individual student presentations	2
Se2-7	Individual students presentations on the current state of knowledge related to the issues of the realized diploma thesis, propose of the direction of further solutions. Discussions in the seminar group on the presented topics	12
Se8-13	Individual presentations about the realized diploma thesis with emphasis on their original achievements with the discussions in the seminar group.	12
Se14	Individual presentations - additional term	2
Se15	Crediting with grade	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Multimedia presentation
N2	Problematic discussion
N3	Individual work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01, PEU_U02, PEU_U03	Average rating for presentations, the ability to justify the advisability of the proposed solutions and the substantive referring to the proposals of other seminar participants.
F2	PEU_K01, PEU_K02, PEU_K03	Average rating for timely execution of the presentations, for the culture of speech, the ability to behave in a group and conduct discussions, for creativity and entrepreneurship.
P1=(2*F1+F2)/3		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	1. Literature related to the issues of the thesis
Secondary literaturę	
1	

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

Imię i nazwisko:	Dean of the Faculty
E-mail:	

Master seminar

Faculty of	**Mechanical and Power Engineering**
Name in English	**Master seminar RAC**
Name in Polish	**Seminarium dyplomowe**
Main field of study	**Power Engineering**
Specialization	**Refrigeration and cryogenic**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional**
Subject code	**W09ENG-SM2369**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					50
Form of crediting					Zaliczenie
For group of courses mark final course with (X)					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					2
including number of ECTS points for direct teacher-student contact (BU) classes					1,28

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Passing all subjects covered by the plan of study in semesters prior to graduation semester ("Diploma seminar" course is accompanied by the "Master of Science Diploma Dissertation" course).

SUBJECT OBJECTIVES

C1	Improving skills in the search for selective knowledge needed to create their own original ideas and solutions, and prepare a presentation that allows pass them on to others meaningful way
C2	Improving the ability to lead creative discussion during which can be justify the proposed solutions or ideas in a concrete and innovations
C3	Improving skills in the dissertation writing on a specific topic, presenting their own achievements against the background of known existing solutions
C4	Shaping the beliefs about the need for permanent development of their personality in all its aspects
C5	Developing a sense of conscientiousness and responsibility for the undertaken commitments, both to themselves and to others

SUBJECT LEARNING OUTCOMES

relating to skills:	
PEU_U01	Student can obtain information from a various sources necessary to comply energy systems projects in order to improve existing solutions
PEU_U02	Student can prepare a coherent paper or presentation on the work carried out, containing the results of the proposed design solutions, technological or operational

PEU_U03	Student is able to objectively justify the desirability of his/her original ideas and solutions during the discussion and critically evaluate the technical solutions proposed by others
relating to social competences:	
PEU_K01	Student understands the need to improve their professional and personal competence, is aware of the social consequences of engineering activities
PEU_K02	Student is able to cooperate and actually behave in a group, actively participate in the discussions on the professional topics with cultural expression and respect for different views of other participants in the discussion
PEU_K03	Student can think and act in a creative and enterprising manner, is able to define the priorities which determine the success of a scheduled task

PROGRAMME CONTENT

seminar		Number of hours
Se1	Discussion of the substantive requirements of the diploma thesis, structure and scope the different types of dissertations. Presentation of the general principles of conduct the final exam. Set a schedule of the individual student presentations	2
Se2-7	Individual students presentations on the current state of knowledge related to the issues of the realized diploma thesis, propose of the direction of further solutions. Discussions in the seminar group on the presented topics	12
Se8-13	Individual presentations about the realized diploma thesis with emphasis on their original achievements with the discussions in the seminar group.	12
Se14	Individual presentations - additional term	2
Se15	Crediting with grade	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Multimedia presentation
N2	Problematic discussion
N3	Individual work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01, PEU_U02, PEU_U03	Average rating for presentations, the ability to justify the advisability of the proposed solutions and the substantive referring to the proposals of other seminar participants.
F2	PEU_K01, PEU_K02, PEU_K03	Average rating for timely execution of the presentations, for the culture of speech, the ability to behave in a group and conduct discussions, for creativity and entrepreneurship.
P1=(2*F1+F2)/3		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	1. Literature related to the issues of the thesis
Secondary literaturę	
1	

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

Imię i nazwisko:	Dean of the Faculty
E-mail:	

Master seminar

Faculty of	**Mechanical and Power Engineering**
Name in English	**Master seminar RSE**
Name in Polish	**Seminarium dyplomowe**
Main field of study	**Power Engineering**
Specialization	**Renewable Sources of Energy**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional**
Subject code	**W09ENG-SM2359**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					50
Form of crediting					Zaliczenie
For group of courses mark final course with (X)					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					2
including number of ECTS points for direct teacher-student contact (BU) classes					1,28

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Passing all subjects covered by the plan of study in semesters prior to graduation semester ("Diploma seminar" course is accompanied by the "Master of Science Diploma Dissertation" course).

SUBJECT OBJECTIVES

C1	Improving skills in the search for selective knowledge needed to create their own original ideas and solutions, and prepare a presentation that allows pass them on to others meaningful way
C2	Improving the ability to lead creative discussion during which can be justify the proposed solutions or ideas in a concrete and innovations
C3	Improving skills in the dissertation writing on a specific topic, presenting their own achievements against the background of known existing solutions
C4	Shaping the beliefs about the need for permanent development of their personality in all its aspects
C5	Developing a sense of conscientiousness and responsibility for the undertaken commitments, both to themselves and to others

SUBJECT LEARNING OUTCOMES

relating to skills:	
PEU_U01	Student can obtain information from a various sources necessary to comply energy systems projects in order to improve existing solutions
PEU_U02	Student can prepare a coherent paper or presentation on the work carried out, containing the results of the proposed design solutions, technological or operational

PEU_U03	Student is able to objectively justify the desirability of his/her original ideas and solutions during the discussion and critically evaluate the technical solutions proposed by others
relating to social competences:	
PEU_K01	Student understands the need to improve their professional and personal competence, is aware of the social consequences of engineering activities
PEU_K02	Student is able to cooperate and actually behave in a group, actively participate in the discussions on the professional topics with cultural expression and respect for different views of other participants in the discussion
PEU_K03	Student can think and act in a creative and enterprising manner, is able to define the priorities which determine the success of a scheduled task

PROGRAMME CONTENT

seminar		Number of hours
Se1	Discussion of the substantive requirements of the diploma thesis, structure and scope the different types of dissertations. Presentation of the general principles of conduct the final exam. Set a schedule of the individual student presentations	2
Se2-7	Individual students presentations on the current state of knowledge related to the issues of the realized diploma thesis, propose of the direction of further solutions. Discussions in the seminar group on the presented topics	12
Se8-13	Individual presentations about the realized diploma thesis with emphasis on their original achievements with the discussions in the seminar group.	12
Se14	Individual presentations - additional term	2
Se15	Crediting with grade	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Multimedia presentation
N2	Problematic discussion
N3	Individual work

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01, PEU_U02, PEU_U03	Average rating for presentations, the ability to justify the advisability of the proposed solutions and the substantive referring to the proposals of other seminar participants.
F2	PEU_K01, PEU_K02, PEU_K03	Average rating for timely execution of the presentations, for the culture of speech, the ability to behave in a group and conduct discussions, for creativity and entrepreneurship.
P1=(2*F1+F2)/3		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	1. Literature related to the issues of the thesis
Secondary literaturę	
1	

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

Imię i nazwisko:	Dean of the Faculty
E-mail:	

Mechatronics and control systems

Faculty of	**Mechanical and Power Engineering**
Name in English	**Mechatronics and control systems**
Name in Polish	**Mechatronika i systemy sterowania**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2333**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,28		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic competences in mathematics and physics as acquired on the 1st level studies
2.	Basic knowledge of electric circuit theory and electromagnetism as acquired on the 1st level studies.

SUBJECT OBJECTIVES

C1	C1 Acquisition of the basic knowledge regarding the following parts of a mechatronic system: C1.1 Sensors of physical quantities C1.2 Actuators C1.3 Control systems and devices – microcontrollers, PLC controllers.
C2	C2 Acquisistion of the basic qualifications regarding: C2.1 The design methodology of the structure of a mechatronic system C2.2 The parametrization of the components deployed in a mechatronic system C2.3 Design and software implementation of the control algorithm for a control system.
C3	C3 Social competence enhancement C3.1 Acquiring and enhancing of the social competences regarding teamwork and co-operation during implementation of projects.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	the student is able to define a model of a mechatronic system
PEU_W02	the student has the basic knowledge regarding sensors
PEU_W03	the student knows the fundamentals of microcontroller programming

PEU_W04	the student knows the fundamentals of PLC programming
PEU_W05	the student is familiar with the internal structure & operation of a microcontroller
relating to skills:	
PEU_U01	the student is able to define and evaluate the technical parameters of a mechatronic system
PEU_U02	the student is able to design & assemble a simple test circuit with a microcontroller
PEU_U03	the student is able to specify and select sensors and actuators for a particular mechatronic system
PEU_U04	the student is capable of writing of simple control programs for a PLC controller used in a particular technological process
PEU_U05	the student is able to design and build a simple mechatronic system using a PLC controller together with sensors and actuators
relating to social competences:	
PEU_K01	the student is able to search for technical information by his own hand
PEU_K02	the student is prepared to mutual co-operation during teamwork

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction, Basic ideas, relations between mechatronics and other scientific disciplines	2
Wy2	Programmable control systems – an introduction. Process algorithms, Turing machine, von Neumann computer architecture.	2
Wy3	Microcontrollers – an introduction, basic ideas, internal architecture	2
Wy4	Microcontrollers – programming methods	2
Wy5	Microcontrollers – interfacing to I/O devices	2
Wy6	Microcontrollers – examples of applications, mobile robots.	2
Wy7	Sensors of fundamental physical quantities (pressure, temperature, displacement)	2
Wy8	Encoders, position sensors, examples of applications.	2
Wy9	Elements of motion transfer systems (gears, clutches, lead screw drives)	2
Wy10	Examples of mechatronic components application – CNC machines	2
Wy11	Mechatronics in biomedical applications – a pneumatic blood pressure wave sensor	2
Wy12	PLC controllers – an introduction, basic ideas.	2
Wy13	PLC controllers – a survey of market solutions and system architectures	2
Wy14	PLC controllers – programming methods, language-based coding of algorithm, exemplary programs	2
Wy15	PLC controllers – large control systems, SCADA software.	2
Total Hours		30

laboratory		Number of hours
La1	Presentation of the course, introduction, safety rules training	2
La2	Microcontrollers – development system with a mictrocontroller (an introduction)	2
La3	C language compiler for microcontrollers – an introduction	2
La4	Interfacing of LED diodes and microswitches with I/O ports of microcontroller	2
La5	Stepping motor service routines using I/O port of a microcontroller.	2
La6	LED display control using microcontroller	2
La7	An alphanumeric LCD display control with a microcontroller	2
La8	Built-in peripheral devices: A/D converter and serial port service routines.	2
La9	Programmable Logic Controllers (PLC)– an introduction. Interfacing of I/O signals to a PLC.	2
La10	PLC – ladder diagram programming (an introduction)	2
La11	PLC – timers and counters service routines	2

La12	PLC – programming of PLC operator panel and extension modules	2
La13	PLC – programming of modular production systems (MPS)	2
La14	PLC – implementation of an individual project, advanced programming methods	2
La15	Additional activities, final assessment.	2
Total Hours		30

TEACHING TOOLS USED		
N1	Lecture:	General lecture, multimedia presentation
N2	Laboratory:	Lab report preparation, self-study accompanied by lab instruction sheets
N3	Consultations with the tutor	

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1 (lecture)	PEU_W01¸PEU_W07, PEU_U01¸PEU_U07, PEU_K01¸PEU_K02	Written examination
F2 (laboratory)	PEU_W01¸PEU_W07, PEU_U01¸PEU_U07, PEU_K01¸PEU_K02	Lab reports assessment, micro-tests during lab sessions
P1=F1 (lecture), P2=F2 (laboratory)		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Cetinkunt S., Mechatronics with Experiments, Wiley 2015
2	Michael B. Histand, David G. Alciatore, Introduction to mechatronics and measurement systems, McGraw-Hill Education, 2007
3	Jędrusyna A.,Tomczuk K.,Mechatronics and Control Systems Handbook. Wyd. PWr 2010.
Secondary literaturę	
1	Dorf. R.C, Modern control systems, 12th Ed., Prentice-Hall 2011
12	

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

Imię i nazwisko:	Artur Jędrusyna
E-mail:	artur.jedrusyna@pwr.edu.pl

Modeling of combustion processes

Faculty of	**Mechanical and Power Engineering**
Name in English	**Modeling of combustion processes**
Name in Polish	**Modelowanie procesów spalania**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**wybieralny**
Subject code	**W09ENG-SM2342**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting	Egzamin		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,84		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge, skills and other competences in the range of: combustion, thermodynamics, fundamentals of fluid mechanics

SUBJECT OBJECTIVES

C1	The course provides an introduction to the subject of combustion process modeling, covering a broad range of topics important to the fields of energy conversion
C2	To familiarize students with the basic aspects and equations describing the thermodynamics and gas dynamics in combustion process
C3	To develop knowledge in basic mathematical description of processes occurring in combustion systems

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	understand the physical and chemical aspects of combustion processes
PEU_W02	understand chemical kinetics and chemistry of combustion. The role of elementary and global reactions. Reaction rate expressions
PEU_W03	understand conversion formulas and thermochemical properties of the system. Heat of reaction and adiabatic flame temperature
PEU_W04	understand chemical equilibrium and composition calculation
PEU_W05	understand combustion modelling issues without transport. Ideal reactor studies

PEU_W06	understand combustion modelling issues with transport. Reactive flow and transport phenomena. Turbulent combustion modelling
PEU_W07	understand standard turbulent combustion models and their limitations which are implemented in commercial CFD software packages
relating to skills:	
PEU_U01	solve simple combustion problems by using the physical and chemical fundamentals of combustion processes
PEU_U02	calculate the stoichiometry, adiabatic flame temperature and heat of combustion of a fuel and oxidizer mixture
PEU_U03	use chemistry software to solve simple 0/1-d combustion problems such as perfectly stirred reactors
relating to social competences:	
PEU_K01	Soft skills during team work

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Practical Applications of Combustion Modelling	2
Wy2	Chemical reactions	2
Wy3	Conversion Formulas. Thermochemical Properties	2
Wy4	Reaction Rate Expressions	2
Wy5	Complex Chemical Equilibrium. Compositions	2
Wy6	Heat of Reaction. Adiabatic Flame temperature.	2
Wy7	Differential equations of chemical reaction without transport	2
Wy8	The Continuously Stirred Tank Reactor	2
Wy9	Modelling of autoignition	2
Wy10	Mechanism reduction	2
Wy11	Introduction to reactive flow. Transport Equations.	2
Wy12	Laminar premixed and diffusion flames.	2
Wy13	Turbulent combustion modelling.	2
Wy14	Standard for modeling and simulating complex gas phase chemistry reactions	2
Wy15	Summary	2
Suma godzin		30

laboratory		Number of hours
La1	Calculation of thermochemical properties of gas using coefficients in NASA format	2
La2	Calculation of theoretical flame temperature	2
La3	The standard heat of combustion of gases	2
La4	Callculation of equilibrium compositions	2
La5	Callculation of equilibrium compositions	2
La6	Adiabatic flame temperature	2
La7	Adiabatic flame temperature	2
La8	Application of the reaction ordinate variable in the analysis of equilibrium states	2
La9	Model PSR (mixture: (H2-O2)) - use chemistry software	2
La10	Model PSR (mixture: (H2-O2)) - use chemistry software	2
La11	Model PSR – evaluating NO emission - use chemistry software	2
La12	Modelling reactive flow with transport equations	2
La13	Modelling turbulent reactive flow	2
La14	Modelling turbulent reactive flow	2
La15	Modelling turbulent reactive flow	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Traditional lecture with the use of multi-media presentation
N2	Tutorials using dedicated software
N3	Consultations.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01 ÷ PEU_U03	Final test
F2	PEU_U01 ÷ PEU_U03	Activity
P1	PEU_W01÷PEU_W07	Exam

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Gas phase combustion chemistry” - Gardiner 2000
2	Introduction to Chemical Engineering Thermodynamic, J.M. Smith, H.C. Van Ness, M.M. Abbot, M.T. Swihart
3	Theoretical and numerical combustion, T.Poinsot, D.Veynante, 2005
Secondary literaturę	
1	An-Introduction-to-Computational-Fluid-Dynamics, H. Versteeg, 2007

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

Imię i nazwisko:	dr hab. inż. Norbert Modliński
E-mail:	norbert.modlinski@pwr.edu.pl

Modeling of Energy systems

Faculty of	**Mechanical and Power Engineering**
Name in English	**Modeling of Energy systems**
Name in Polish	**Modelowanie systemów energetycznych**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2341**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	25		50		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basic knowledge of thermodynamics, heat transfer, machine design and energy generation in power plant and CHP
2.	Basic knowledge of a chosen worksheet (eg. Excel, Mathcad)

SUBJECT OBJECTIVES

C1	Demonstrate an understanding of the fundamentals and laws governing energy conversion
C2	Discuss issues related to the performance of conventional power-generation plants.
C3	Present trends toward renewable sources of electricity.
C4	A study of steam generation and utility plants, including cogeneration, gas turbine, and combined cycles
C5	Demonstrate features of advanced power plants
C6	Perform engineering calculations.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Demonstrate a comprehensive understanding of the fundamentals and laws governing conversion of energy
PEU_W02	Perform the analysis of cogeneration, combined and integrated cycles for conventional and advanced technologies
PEU_W03	Understand the operation and major components of electricity generating and CHP plants
PEU_W04	Select the type of plant appropriate for a given application.
PEU_W05	Perform basic analyses associated with each subsystem and component of the plant.
PEU_W06	Overall picture of the applied fields for cogeneration systems

PEU_W07	Define mathematical model to assess particular energy system
relating to skills:	
PEU_U01	Perform engineering calculations encountered in practice.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introductory lecture. Energy and electricity fundamentals. Terminology. Numerical Steam Tables.	1
Wy2	Steam power plants. Thermodynamic principles. Fuels. Steam power generation cycles. Nuclear Power Plant	2
Wy3	Steam power plants. Performance improvement. Mathematical modeling.	2
Wy4	Gas turbine and combined-cycle power plants: Gas turbine engines and performance. Gas turbine cycles. Combined-cycle power plants.	2
Wy5	CHP systems: CHP schemes (micro-scale CHP systems, small scale CHP systems, large scale CHP systems including district heating schemes).	2
Wy6	Organic Rankine Cycle. Numerical Tables of different working fluids. Mathematical modelling.	2
Wy7	National Energy System	2
Wy8	Course summary	2
Suma godzin		15

laboratory		Number of hours
La1	Numerical Steam Tables in a chosen worksheet – simple examples.	2
La2	Analysis of simple conventional power plant system. Defining algorithm.	2
La3	Analysis of simple conventional power plant system. Defining algorithm. Optimization problem	2
La4	Analysis of Nuclear Power Plant steam turbine cycle. Defining algorithm.	2
La5	Analysis of Nuclear Power Plant steam turbine cycle. Defining algorithm.	2
La6	Analysis of simple and complex gas turbine energy systems.	2
La7	Analysis of simple and complex gas turbine energy systems.	2
La8	Analysis of simple and complex gas turbine energy systems.	2
La9	Basic design of energy sytems project utilizing renewable sources of energy and waste heat – numerical analysis of ORC.	2
La10	Basic design of energy sytems project utilizing renewable sources of energy and waste heat – numerical analysis of ORC	2
La11	Analysis of simple and complex energy systems – using commercial tool.	2
La12	Analysis of simple and complex energy systems – using commercial tool.	2
La13	Simple National Energy System Simulator	2
La14	Analysis of monitoring and diagnostic systems data. – processing and analysis of DCS power plant unit system in Excel and MathCad	2
La15	Final test	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Lecturing with multimedia - computer presentation
N2	Calculation worksheets MathCad, scrypt language Python Excel and engineering tool CYCLE-TEMPO, Ebsilon
N3	Case studies
N4	Discussion and consultancy.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01	Activity, final test
P1	PEU_W01÷PEK_W07	Final test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	M. M. El-Wakil, Powerplant Technology, McGraw-Hill, 1984 or 2002.
2	Culp, Principles of Energy Conversion, 2nd Edition, 1991.
3	Weisman & Eckart, Modern Power Plant Engineering, 1985
4	Combined-Cycle Gas & Steam Turbine Power Plants. Kehlhofer, R..ISBN 0-88173-076-9
Secondary literaturę	
1	Nye, David E. Consuming Power: A Social History of American Energies. The MIT Press: Cambridge, MA, 1999

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

Imię i nazwisko:	dr hab. inż. Norbert Modliński
E-mail:	norbert.modlinski@pwr.edu.pl

Modeling of HVAC systems

Wydział	**Mechaniczno-Energetyczny**
Nazwa w języku polskim	**Modeling of HVAC systems**
Nazwa w języku angielskim	**Modelowanie systemów HVAC**
Kierunek studiów	**Energetyka**
Specjalność	**-**
Stopień	**II stopień**
Forma	**stacjonarna**
Rodzaj przedmiotu	**obowiązkowy**
Kod przedmiotu	**W09ENG-SM2337**
Grupa kursów	**NIE**

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	15		30		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	25		50		
Forma zaliczenia	Zaliczenie		Zaliczenie		
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	1		2		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			2		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	0,68		1,36		

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1.	Competence in thermodynamics and heat exchange
2.	Basic knowledge of issues related to air conditioning and heating

CELE PRZEDMIOTU

C1	To familiarize students with the basic elements of HVAC installations.
C2	To familiarize students with the principle of operation and operation of HVAC systems.
C3	To familiarize students with examples of real HVAC systems.
C4	To develop skills in performing simulations for simple and complex HVAC installations.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

Z zakresu wiedzy:	
PEU_W01	Has knowledge of the various elements of the HVAC system.
PEU_W02	Has knowledge of the principles of operation and use of HVAC systems.
Z zakresu umiejętności:	
PEU_U01	Student is able to present devices included in the HVAC installation.
PEU_U02	Student is able to choose the parameters of the HVAC installation.

TREŚCI PROGRAMOWE

Forma zajęć - wykład		Liczba godzin
Wy1	Introduction. Fundamentals of thermal comfort, psychrometrics, and thermodynamics	1
Wy2	The load sub-system air-conditioning equipment	2
Wy3	The heat and hot water production sub-system	2
Wy4	The cold production sub-system	2
Wy5	Thermal energy storage methods: sensible and latent	2
Wy6	Seasonal thermal energy storage for heating and cooling capacity	2
Wy7	Introduction to district heating and cooling systems	2
Wy8	Final test	2
Suma godzin		15

Forma zajęć - laboratorium		Liczba godzin
La1	Introduction to the course and TRNSYS Software	2
La2-14	Simulating the operation of selected HVAC installations	26
La15	Additional term	2
Suma godzin		30

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1	Informative lecture using a multimedia presentation
N2	Students' own work - preparation for passing
N3	Consultations
N4	The program for conducting simulations - TRNSYS v. 18.

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ

Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1		
P1		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

Literatura podstawowa	
1	Wang SK, Handbook of air conditioning and refrigeration. 2nd ed. McGraw-Hil; 2011.
2	Cengel Y, Heat Transfer: a practical approach. 2nd ed. WCBMcGraw-Hill, United States of America; 1998.
3	Duffie JA and Beckman WA, Solar Engineering of thermal processes, 2nd ed. John Wiley and Sons.
4	Dincer I and Rosen MA,Thermal energy storage systems and applications, 2nd ed. John Wiley and Sons; 2011.
Literatura uzupełniająca	
1	Applied Energy Journal
2	Renewable Energy Journal
3	Solar Energy Journal

OPIEKUN PRZEDMIOTU

Imię i nazwisko:	Magdalena Nemś
E-mail:	Magdalena.nems@pwr.edu.pl

New generation energy technologies

Faculty of	**Mechanical and Power Engineering**
Name in English	**New generation energy technologies**
Name in Polish	**Technologie energetyczne nowej generacji**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2335**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,28				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Competence in the field of thermodynamics, combustion process and fuels confirmed at the degree courses of study
2.	

SUBJECT OBJECTIVES

C1	Detailed familiarize students with the development trends of the latest technologies used in the power plant industry, and with some problems with their implementations
C2	

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	knows the problems of the development trends and the most important developments related to the latest technologies used in the power industry, the development trends and problems in their implementation
PEU_W02	

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Lec1	Conventional energy generation systems	2
Lec2	Energy generation in an Integrative Gasification Combination Cycle (IGCC) system	2
Lec3	OXY fuel technology, CO2 separation and storage	2
Lec4	Technical solutions for future power plants	2

Lec5	Hydrogen - an alternative to conventional power generation	2
Lec6	Power generation using supercritical circulation of CO2 (S-CO2)	2
Lec7,8	Advanced nuclear power reactor technologies	4
Lec9	Basic safety principles for nuclear power plants	2
Lec10	Small modular nuclear reactor SMR technologies	2
Lec11	Generation IV nuclear reactors	2
Lec12	Basic fusion reactions and basics of nuclear fusion.	2
Lec13	Basics of plasma physics and possibilities of controlling and maintaining plasma.	2
Lec14	Discussion of selected nuclear fusion experiments.	2
Lec15	Crediting with grade	2
Total hours		**30**

TEACHING TOOLS USED	
N1	Information and problem lecture in the form of a multimedia presentation
N2	Consultations
N3	

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P	PUE_W01	Crediting with grade
P2		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Alexander V. Dimitrov, Introduction to Energy Technologies for Efficient Power Generation, 1st Edition, CRC Press 2017
2	Paul Breeze, Power Generation Technologies, 3rd Edition, Newnes 2019
3	Jean-Claude Sabonnadière (Ed.), Renewable Energy Technologies, Wiley-ISTE 2010
4	Kok K.D., Nuclear Engineering Handbook, 2009
5	Wood J., Nuclear Power, 2007
6	Kenro Miyamoto, Fundamentals of Plasma Physics and Controlled Fusion, NIFS-PROC-48 by National Institute of Fusion Science (NIFS) in Tokio.
Secondary literature	
1	Tadeusz J. Chmielniak, Technologie energetyczne, Wydawnictwo Politechniki Śląskiej 2004
2	Krzysztof Chmielowiec, Zbigniew Hanzelka, Andrzej Firlit Red., Elektrownie ze źródłami odnawialnymi: zagadnienia wybrane, Kraków : Wydawnictwa AGH 2015
3	Cacuci D.G., Handbook of Nuclear Engineering. 2010
4	

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

Name and surname:	Wojciech Moroń	
E-mail:	wojciech.moron@pwr.edu.pl	

Numerical methods

Faculty of	**Mechanical and Power Engineering**
Name in English	**Numerical methods**
Name in Polish	**Metody numeryczne**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2346**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting	Egzamin		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	0,84		1,36		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Fundamentals of mathematical analysis, algebra and geometry in mathematics
2.	Mathematical calculus and syntax used for computer based calculation
3.	Basic knowledge of physics phenomena

SUBJECT OBJECTIVES

C1	Acquisition of basic numerical methods knowledge essential for solving engineering problems. Improving the state of knowledge in the field of computer-based calculations.
C2	Obtaining skill of creating programs utilizing basic algorithms of numerical methods with use of approximation, interpolation, numerical integration and differentiation, solving nonlinear algebraic equations and differential equations.
C3	Developing the ability to use the selected numerical techniques to process measurement data and solve real-life engineering problems.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Understanding the numerical calculations process based on a finite digit representation and accuracy related problems.
PEU_W02	Understanding the concept of numerical interpolation and ability to construct interpolation polynomials and spline functions. Ability to estimate the interpolation error.
PEU_W03	Knowledge of data processing with least square approximation method for any set of basis functions.

PEU_W04	Knowledge of numerical integration and differentiation methods. Knowledge of error source and methods of its estimation.
PEU_W05	Knowledge of methods for solving non-linear equations and systems of linear equations.
relating to skills:	
PEU_U01	Use of MATLAB/Octave built in functions and basic programming operations. Creating plots and user defined functions.
PEU_U02	For a given set of points student know how to find an interpolating polynomial or create spline function
PEU_U03	Student is able to determine the integral value with use of Midpoint, Trapezoid or Simpson method. Based on finite-difference method student is able to determine the value of the derivative.
PEU_U04	With the use of Bisection, Secants, Newton or Fixed-Point method, student can solve non-linear equation
PEU_U05	Solving a system of linear algebraic equations using an algorithm implemented in MATALB
relating to social competences:	
PEU_K01	

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction. Floating point mathematical operations. Precision of arithmetics. Basic information about MATLAB.	1
Wy2-Wy4	Basic operations in MATLAB – Vectors and arrays, Conditional statements, preparation of 2D and 3D plots, *For* and *while* loops, User defined functions.	6
Wy5	Interpolation – Newtons and Lagrange Method for finding interpolating polynomial. Spline functions.	2
Wy6	Least square approximation – derivation of approximation function for any set of basis functions. Approximation with use of non-linear functions.	2
Wy7	Solving non-linear equations and systems of linear equations.	2
Wy8	Numerical integration and differentiation – Midpoint, Trapezoid and Simpson integration methods. Approximation of derivative with finite-difference method.	2
Suma godzin		15

laboratory		Number of hours
La1	Arithmetic operations, familiarization with the MATLAB environment	2
La2	Vectors and arrays	2
La3	Operations on vectors and arrays	2
La4	Conditional statements, preparation of 2D and 3D plots	2
La5	*For* and *while* loops	2
La6	Test of knowledge of the basics of programming in the MATLAB environment	2
La7	Interpolation using MATLAB functions, Vandermonde and Lagrange method	2
La8	Newton's interpolation. Interpolation error.	2
La9	Spline functions.	2
La10	Least square approximation.	2
La11	Solving non-linear equations - Newton's method, secants method	2
La12	Solving non-linear equations - fixed point iteration method, bisection method	2
La13	Solving system of linear equations. Gauss and LU decomposition method.	2
La14	Numerical integration – midpoint and trapezoid method, Simpson's method, Richardson's extrapolation.	2
La15	Numerical differentiation - finite differences method	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Traditional lecture using multimedia presentation
N2	Individual work - self-study based on supervisor materials, application books, code samples and examples.
N3	Laboratory work work - solving problem lists during laboratory classes
N4	Individual work – solving selected engineering problem and presentation of results in report form

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01, PEU_W01	Basic matlab knowledge test. (La6)
F2-F5	PEU_U02- PEU_U05	Reports, laboratory entry tests
F6-F10	PEU_W01- PEU_W05	Reports, laboratory entry tests, partial tests during lecture.

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	A. Gilat, *MATLAB: An Introduction with Applications*, John Wiley & Sons, Inc., 2010
2	A. Gilat, *Numerical Methods for Engineers and Scientists. An Introduction with Applications using MATLAB*, John Wiley & Sons, Inc., 2014
3	D. Kincaid, W. Cheney, *Numerical Analysis. Mathematics of Scientific Computing",* Wadsworth, 2002
5	G. Dahlquist, A. Bjorck, *Numerical Methods in Scientific Computing .vol.* I, SIAM, 2008
6	A. Quarteroni, F. Saleri, *Scientific Computing with Matlab and Octave*, Springer , 2006
Secondary literaturę	
1	J. Kiusalaas , *Numerical Methods in Engineering with Matlab*, Cambridge, 2005.
2	J. H. Mathews, K. D. Fink, *Numerical Methods Using Matlab*,Prentice Hall, 1999
3	G.W. Recktenwald, *Numerical methods with MATLAB - implementations and applications*, Prentice Hall Inc. 2000, New Jersey

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

Imię i nazwisko:	Dr inż. Dominik Błoński
E-mail:	dominik.blonski@pwr.edu.pl

Physics - selected issues

Faculty of	**Mechanical and Power Engineering**
Name in English	**Physics - selected issues**
Name in Polish	**Fizyka - zagadnienia wybrane**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2332**
Group of courses	**NO**

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	25				
Form of crediting	control work				
For group of courses mark final course with (X)					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	0,68				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Competence in knowledge of mathematics and physics as evidenced by passing grades in Physics and mathematics courses in the first degree program

SUBJECT OBJECTIVES

C1	To familiarize students with the basic quantum phenomena and tools of quantum physics and prepare them to use quantum phenomena in energy and cryogenics

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has a structured and theoretically supported detailed knowledge of basic quantum phenomena, about the tools used in quantum physics, about the connections of quantum physics with energy and cryogenics

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction	1
Wy2-4	Wave and operator description of physical phenomena	6
Wy5-7	Quantum effects - use in science and technology	6
Wy8	Summary & colloqium	2
Summary		15

TEACHING TOOLS USED	
N1	informative-problematic lecture, multimedia presentation combined with traditional form

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1=P1	PEU_W01	A written or oral colloquium

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Wichman E.H.,Quantum Physics", any addition.
2	Matthews P.T., „An Introduction to Quantum Mechanics", any edition.
Secondary literature	
1	L.D.Landau, E.M.Lifszyc, „Quantum Mechanics", any edition.
2	R.P.Feynman, R.B.Leighton, M.Sands, „The Feynman Lecture of Physics" ; any edition.

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

Imię i nazwisko:	dr hab. inż. Dorota Nowak-Woźny, prof. uczelni
E-mail:	dorota.nowak-wozny@pwr.edu.pl

Physics of renewable energy

Faculty of	**Mechanical and Power Engineering**
Name in English	**Physics of renewable energy**
Name in Polish	**Fizyczne podstawy energetyki odnawialnej**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2336**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	15
Number of hours of total student workload (CNPS)	75			25	25
Form of crediting	Exam			Credit	Credit
For group of courses mark final course with (X)					
Number of ECTS points	3			1	1
including number of ECTS points for practical (P) classes				1	1
including number of ECTS points for direct teacher-student contact (BU) classes	1,44			0,76	0,68

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Competence in mathematics and physics confirmed by positive grades in physics and mathematics at the first level of study

SUBJECT OBJECTIVES

C1	Detailed familiarization of students with the phenomena and physical processes used in energetics from renewable sources, taking into account new achievements and development trends
C2	Developing skills to effectively acquire, critically evaluate and use information, including energy sources, for using in practice
C3	Preparing students for the implementation of project tasks, including the use of current achievements related to physics and material engineering
C4	To develop skills in public presentations of the results of literature studies and project work

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	has structured and theoretically founded detailed knowledge related to issues in the field of physical phenomena and processes used in renewable energy as well as the most important new achievements and development trends in the field of energy from renewable sources
relating to skills:	
PEU_U01	can obtain information from literature, databases and other sources; make a critical assessment of them, on this basis can design a simple energy system based on renewable energy sources, taking into account the

	initial economic analysis and is able to draw conclusions and formulate and comprehensively justify opinions as well as prepare a report
PEU_U02	can prepare the presentation on the topic of renewable energy, lead the discussion and evaluate its course
relating to social competences:	
PEU_K01	can lead a discussion

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Preface, course organization, requirements.	2
Wy2	Introduction: basic problems associated with the energy production systems; the model of the greenhouse effect Characteristics of solar radiation as an energy source: solar emission spectrum, interaction with the atmosphere, clear sky model - calculations of insolation, Liu-Jordan correlation - calculations at different climatic conditions, solar systems. Characteristics of solar radiation as an energy source: solar emission spectrum, interaction with the atmosphere, clear sky model - calculations of insolation, Liu-Jordan correlation - calculations at different climatic conditions, solar systems - continuation	8
Wy3	Direct conversion of the solar radiation to the electricity: photoelectric effect, PV systems and their operating conditions, PV technology Direct conversion of the solar radiation to the electricity: photoelectric effect, PV systems and their operating conditions, PV technology - continuation Direct conversion of the IR solar radiation to the electricity: thermoelectric effect, thermoelectric generator and heat pump. Direct conversion of the IR solar radiation to the electricity: thermoelectric effect, thermoelectric generator and heat pump - continuation	10
Wy4	Thermionic effect and its applications. AMTEC & fuel-cells – continuation. Thermoacoustic, thermoacoustic generator, heat pump and refrigerator. Thermoacoustic, thermoacoustic generator, heat pump and refrigerator- continuation. Waves and tidal – physics and characteristics from the energy source point of view Waves and tidal – physics and characteristics from the energy source point of view Wind energy. Nuclear fusion.	8
Wy5	The supplement or the summary according to student suggestions	2
Suma godzin		30

project		Number of hours
Pr1	Introduction	1
Pr2	The establishing of the project assumptions and the project's tasks related to project implementation - localization, selection of the energy sources, selection of the energy system. The project's calculations: power obtained from the selected source of energy depending on localization and climate conditions - analysis of obtained results	10
Pr3	Students present their design solutions at the whole group forum - summary, discussion and evaluation	4
Suma godzin		15

seminar		Number of hours
Se1	Introduction	1
Se2	The student's reports on renewable energy with particular emphasis on the physics of the phenomena and technical solutions discussed, as well as development trends - discussion and assessment of the speech.	14
Suma godzin		15

TEACHING TOOLS USED	
N1	Lecture: information and problem lecture, multimedia presentation combined with traditional form,
N2	Seminar: multimedia or traditional presentation, discussion
N3	Project: own work, consultation, multimedia / traditional presentation of work stages, discussion of the results obtained, final report.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1=P1	PEU_W01	Exam
F2=P2	PEU_U01	Report & presentation
F3=P3	PEU_U02	Presentation & discussion

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Gilbert M. Masters, „*Renewable and efficient electric power systems”*, WILEY-INTERSCIENCE, 2004
2	Sorensen B., „*Renewable energy*:”, San Diego Academic Press,2000
3	Aden B. Meinel, Marjorie P. Meinel, „*Applied solar energy, An Introduction*“, Addison-Wesley Publishing Company,1997
4	Aldo Viera da Rosa, “*Fundamentals of Renewable Energy Processes*”, Elsevier Academic Press, 2005
Secondary literaturę	
1	Gipe P., “Wind energy for the rest of us”, any edition
2	Boxwell M., Solar Electricity Handbook, any edition
3	“*Some aspects of renewable energy*”, scientific editors: D.Nowak-Woźny, M.Mazur, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2011

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

Imię i nazwisko:	Dr hab. inż. Dorota Nowak-Woźny
E-mail:	dorota.nowak-wozny@pwr.edu.pl

Project management at energy sector

Faculty of	**Mechanical and Power Engineering**
Name in English	**Project management at energy sector**
Name in Polish	**Zarządzanie projektami w energetyce**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional**
Subject code	**W08W09-SM1111**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	75				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	3				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,28				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	No prerequisites

SUBJECT OBJECTIVES

C1	Provide students with knowledge about project management
C2	Providing students with knowledge about the implementation of projects in the energy sector

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge of projects, knows the basic components of the project and knows how to manage them.
PEU_W02	Knows and understands the basic conditions related to the implementation of projects in the energy sector
relating to social competences:	
PEU_K01	He is ready to think and act in a project team

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Wy1	Organizational classes. Presentation of the objectives and scope of the course and the conditions for passing. Introduction to project management	2
Wy2	The essence of sustainable development. Sustainable development and projects. PRiSM essentials.	4
Wy3	Project - definition, types, components, methodology.	2
Wy4	Modern project management concepts	2

Wy5	The realization of the project. Planning, preparation and organization of the project.Time, budget and project team management.	2
Wy6	Threats in the project implementation process. Types and sources of risk.	4
Wy7	Preparation of a project offer in the energy sector. Action tactics. Relations among: investor - contractor – competition	2
Wy8	Case studies I. Repairs of electrostatic precipitators filters in large power plants and combined heat plants in Poland. Case reports, photographic documentation, reflections and conclusions.	4
Wy9	Case studies II. Installation for CO2 capture in a large industrial plant.	2
Wy10	Case studies III. RES investments in the implementation of the "zero emission" program for large industrial companies.	2
Wy11	Summary lecture. Scenarios for the development of the energy sector in Poland - at the base of implemented investment projects.	2
Wy12	Final test	2
Suma godzin		30

TEACHING TOOLS USED	
N1	Presentation of knowledge in the form of direct transmission (lecture) - audiovisual means (slides, computer projector).
N2	Lecture materials available in electronic form.
N3	Case studies.
N4	Test.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01 PEU_W02 PEU_K01	Active participation in classes - participation in discussions
F2	PEU_W01 PEU_W02 PEU_K01	Test
P1	P = 04 F1 + 06F2	

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	J. Carboni, W. Duncan, M. Gonzales, P. Milsom. M. Young., Zrównoważone zarzadzanie projektami. Podręcznik GPM. Wyd. pm2pm 2020
2	P. J. Fielding., Zarządzanie projektami. Realizuj zadania w terminie nie przekraczając budżetu, Wyd. Lingea 2021
Secondary literaturę	
1	E. M. Goldratt, Cel I. Doskonałość w produkcji. Wyd. Mintbooks 2008

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

Imię i nazwisko:	Dr inż. Adam Świda
E-mail:	Adam.swida@pwr.edu.pl

Psychology of communication

Faculty of	**Mechanical and Power Engineering**
Name in English	**Psychology of communication**
Name in Polish	**Psychologia komunikacji**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional**
Subject code	**W09-SM-W08HA3**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	50				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	0,68				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	none

SUBJECT OBJECTIVES

C1	

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	knows the terminology of the humanities regarding the phenomena of social psychology, with particular emphasis on the categories of communication, self-presentation and exerting influence
relating to skills:	
PEU_U01	can search, analyze, evaluate, select and integrate information using various sources and formulate critical judgments on this basis
PEU_U02	has the ability to prepare oral presentations on specific issues, using basic theoretical approaches, as well as various sources
relating to social competences:	
PEU_K01	can cooperate and work in a group, assuming various roles in it
PEU_K02	the student is able to think critically and argue his position, thanks to which he can properly define the priorities for the implementation of the tasks set by himself or others

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Psychology of interpersonal relations. Communication. Introduction and crediting conditions.	1
Wy2	Social influence.	2
Wy3	Manipulation and nudge.	2
Wy4	Communication in teams.	2
Wy5	Conflicts.	2
Wy6	Stress.	2
Wy7	Public speaking.	2
Wy8	Practical conclusions for professional practice.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Conversational lecture supported by audiovisual materials
N2	Work in groups
N3	Brainstorm
N4	Individual work of students
N5	Panel discussion
N6	The presentation

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01 PEU_U01 PEU_K02	Final test or a written assignment
F2	PEU_W01 PEU_U01 PEU_U02 PEU_K02	Presentation
F3	PEU_K01 PEU_K02	Activity during classes
P1	P = (F1+F3 or F2+F3)/2	

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Wojciszke B., Człowiek wśród ludzi. Zarys psychologii społecznej, Wydawnictwo Naukowe „Scholar", Warszawa 2002.
2	McKay, M., Davies, M., Fanning, P., Sztuka skutecznego porozumiewania się, GWP 2021
3	Morreale, Spitzberg, Barge, Komunikacja między ludźmi. Motywacja, wiedza, umiejętności, PWN 2015
Secondary literaturę	
1	Cialdini R., Wywieranie wpływu na ludzi. Teoria i praktyka, GWP, Gdańsk 1994.
2	Akerlof, Shiller, Złowić frajera, PTE, Warszawa 2021.
3	Thaler, Sunstein, Impuls, Zysk i S-ka, Poznań 2017.
4	Rosenberg, M., Porozumienie bez przemocy, Czarna Owca, 2016
5	Matthew McKey, Patrick Fanning, Avigail Lev, Michelle Skeen, Relacje na huśtawce, GWP, Sopot 2018
6	John Teasdale, Mark Williams, Zindel Segal, Praktyka uważności, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków 2016
7	Rick Hanson, Forrest Hanson, Rezyliencja, GWP, Sopot 2019

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

Imię i nazwisko:	dr Katarzyna Zahorodna	Anna Kaczmarek
E-mail:	katarzyna.zahorodna@pwr.edu.pl	a.kaczmarek@pwr.edu.pl

Selected problems of thermal-flow processes

Faculty of	**Mechanical and Power Engineering**
Name in English	**Selected problems of thermal-flow processes**
Name in Polish	**Wybrane zagadnienia procesów cieplno-przepływowych**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Subject code	**W09ENG-SM2334**
Group of courses	**NO**

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	25		25		
Form of crediting	Grade		Grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		0,76		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Ability to create 3D geometry in engineering programs.
2.	Knowledge of heat transfer and fluid mechanics

SUBJECT OBJECTIVES

C1	transfer of knowledge about methods of simulation of thermal-flow phenomena
C2	transfer of knowledge on performing and interpreting results of simulations of selected thermal and flow processes
C3	developing skills in selecting appropriate models of multiphase flows
C4	developing skills in performing numerical calculations for models with the implemented radiation model and FSI

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	has knowledge of equations describing heat transfer and fluid movement
PEU_W02	has a view on the phenomenon of turbulence and its models
PEU_W03	has knowledge of methods of numerical solving of heat exchange issues
PEU_W04	be familiar with the methods of numerical solution of inverse problems
PEU_W05	has knowledge of multiphase processes such as condensation and evaporation
PEU_W06	can model radiation-related processes
PEU_W07	has a basic knowledge of the FSI method
relating to skills:	
PEU_U01	can generate geometries and numerical grids

PEU_U02	has the ability to choose the appropriate flow model in multiphase flows
PEU_U03	can perform numerical calculations of steady and transient heat conduction
PEU_U04	can perform numerical calculations of mixing substances in mixers
PEU_U05	can model processes with speeds for which the Mach number is greater than 1

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Organizational issues. Introduction to a heat transfer.	1
Lec2	Solving heat transfer problems	2
Lec3	Mass transfer, turbulence and conjugate heat and mass transfer	2
Lec4	Multiphase flows and discrete phase flows	2
Lec5	Condensation and boiling	2
Lec6	Radiation heat transfer	2
Lec7	Fluid structure interaction FSI	2
Lec8	Final test	2
Total hours		15

laboratory		Number of hours
La1	Organizational issues	1
La2	Transient heat transfer.	2
La3	Modeling of heat transfer by radiation.	2
La4	Modeling of multiphase flows.	2
La5	Modeling of condensation / boiling processes.	2
La6	Modeling of flow containing solid particles.	2
La7	Modeling of the mixing process in a mixer.	2
La8	Modeling of turbine blade flow.	2
Total hours		15

TEACHING TOOLS USED	
N1	Multimedia presentation.
N2	A program for generating geometry and numerical grids, among others ANSYS ICEM or SpaceClaim Geometry.
N3	The program for conducting simulations, among others CFD ANSYS CFX.
N4	Office hours

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01- PEU_U03	Report from Lab 2
F2	PEU_U01- PEU_U03	Report from Lab 3
F3	PEU_U01- PEU_U04	Report from Lab 4
F4	PEU_U01- PEU_U04	Report from Lab 5
F5	PEU_U01- PEU_U04	Report from Lab 6
F6	PEU_U01- PEU_U04	Report from Lab 7
F7	PEU_U01- PEU_U04	Report from Lab 8
P1	PEU_W01- PEU_W07	Final test

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.
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)

Imię i nazwisko:	Przemysław Błasiak
E-mail:	przemyslaw.blasiak@pwr.edu.pl

Solar energy conversion system

Faculty of	**Mechanical and Power Engineering**
Name in English	**Solar energy conversion system**
Name in Polish	**Systemy Konwersji Enrgii Słonecznej**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2352**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15	15	
Number of hours of total student workload (CNPS)	50		25	50	
Form of crediting	Exam		Crediting with grade	Crediting with grade	
For group of courses mark final course with (X)					
Number of ECTS points	2		1	2	
including number of ECTS points for practical (P) classes			1	2	
including number of ECTS points for direct teacher-student contact (BU) classes	0,84		0,76	0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Technical Thermodynamics
2.	Fluid Mechanics

SUBJECT OBJECTIVES

C1	Acquisition of practical knowledge, regarding solar energy conversion systems, their design and application.
C2	Development of skills how to design, measure and analyze solar energy conversion systems

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has knowledge of rules and standards for design and operation of solar energy conversion systems
PEU_W02	Has knowledge of the design of solar energy conversion installations
relating to skills:	
PEU_U01	Can determine the basic parameters of the solar collector and photovoltaic panel.
PEU_U02	Can conclude from the measurements of solar energy conversion systems operating parameters.
PEU_U03	Can calculate parameters related to solar radiation.
PEU_U04	Can design a liquid-based or air-based solar collecto.r

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Overview of the lecture. Introduction. History of solar energy	1
Lec 2 – Lec8	The energy potential of the sun. Classification and types of radiation. The laws of radiation. Classification and division of solar energy conversion systems. Solar energy collectors. Stationary and sun-tracking collectors. Flat-plate, evacuated tube and concentrating collectors. Selection of construction materials for solar collectors. Thermal performance of solar collectors, efficiency, heat capacity of a collector. Theory of the photoelectric effect. Possibilities of converting solar radiation into electricity. PV cell characteristics. Types of PV technology. Related equipment (batteries, charge controllers, inverters, peak-power trackers). Low-temperature heat applications.	14
Total hours		15

laboratory		Number of hours
La1 – La7	Thermodynamic changes of moist air inside the air-based solar collector. Determination of thermal efficiency of the air-based solar collector. Measurements of working parameters of the liquid-based solar collector. Determination of thermal efficiency of the liquid-based solar collector. Measurements of working parameters of the evacuated tube solar collector. Measurements of working parameters of the PV panel. Determination of energy efficiency of the PV panel.	14
La8	Corrective and supplementary classes	1
Total hours		15

project		Number of hours
Pr1	Overview and introduction to the project. Distribution of the individual data for the project.	1
Pr2 – Pr8	Determining the useful time of the designed solar collector for individual design tasks. Calculating of solar radiation value in the assumed period of use of the collector for individual design tasks. Selection of construction materials for the solar collector. Selection of transparent cover for the designed collector. Calculations and selection of collector insulation. Determination of thermal losses of a solar collector. Calculation of the heat power generated by the designed panel. Selection of additional components. Individual consultations. Submission of completed projects.	14
Total hours		15

TEACHING TOOLS USED	
N1	Traditional lecture with presentation of slides.
N2	N2. Laboratory – discussion of problems
N3	Self-study – reading of supplementary materials.
N4	Self-study – working on the individual project.
N5	Self-study – study and preparation to the exam.
N6	Consultation – improvement of knowledge.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01 – PEU_W02	Exam
C2	PEU_U01 – PEU_U02	Reports from laboratory classes
C3	PEU_U03 – PEU_U04	Mark of submitted project

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	[1] 2016 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning Applications (SI Edition), © 2016 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
2	Kreider J. F., 1982. The Solar Heating Design Process. McGraw-Hill, New York
3	Hsieh J. S., 1986. Solar Energy Engineering. Prentice-Hall, Englewood Cliffs, NJ
Secondary literature	
1	Duffie J. A., Beckman W. A., 2006. Solar Engineering of Thermal Processes, third ed. Wiley & Sons, New York
2	Norton B., 1992. Solar Energy Thermal Technology. Springer-Verlag, London

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

Name and surname:	Bogusław Białko
E-mail address:	boguslaw.bialko@pwr.edu.pl

Sorption refrigeration

Faculty of	**Mechanical and Power Engineering**
Name in English	**Sorption refrigeration**
Name in Polish	**Chłodnictwo sorpcyjne**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2367**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	25	25			
Form of crediting	Zaliczenie	Zaliczenie			
For group of courses mark final course with (X)					
Number of ECTS points	1	1			
including number of ECTS points for practical (P) classes		1			
including number of ECTS points for direct teacher-student contact (BU) classes	0,68	0,68			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Basics of thermodynamics
2.	Basics of heat transfer
3.	Basics of fluid dynamics

SUBJECT OBJECTIVES

C1	Familiarize students with the construction and operation of sorption energy systems and the properties of working solutions.
C2	To familiarize students with the modeling of sorption systems processes by the graphical method and the use of a computer program.
C3	Familiarize students with the possibilities of using low-temperature heat sources and waste heat.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Has structured knowledge of the thermodynamic fundamentals, construction and operation of sorption energy systems.
PEU_W02	Has a structured knowledge of process energy balancing and thermal calculation of sorption apparatuses of energy systems.
relating to skills:	
PEU_U01	Knows how to identify and balance sorption circuit processes of energy systems.
PEU_U02	Knows how to calculate and select apparatuses of sorption energy systems.

relating to social competences:	
PEU_K01	Is able to concisely present the results of his work.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Scope of the lecture, credit conditions, literature. Characterization of the basic concepts and definitions from the thermodynamics of solutions, needed for modeling the absorption cycle.	1
Wy2	The principle of operation of absorption equipment. Properties of working vapors and their influence on the design of absorption systems. Construction of the h-ksi diagram for aqueous ammonia solution. Construction of the h-ksi and lgp-t diagram for an aqueous solution of lithium bromide.	2
Wy3	Application of thermodynamic balancing principles to model the sorption cycle. Thermal balance of an ammonia sorption system on an h-ksi diagram. Substance and thermal balances of partial processes.	2
Wy4	Principles of operation and thermal and hydraulic calculations of absorbers, desorbers and rectifiers of water-ammonia sorption systems, overview of the design.	2
Wy5	Principles of operation and thermal and hydraulic calculations of absorbers, desorbers and rectifiers of water-lithiumbromide sorption systems.	2
Wy6	Adsorption and desorption processes in refrigeration systems - principle of operation of adsorption equipment.	2
Wy7	Adsorption and desorption processes in refrigeration systems - working pairs.	2
Wy8	Credit	2
Suma godzin		15

classes		Number of hours
Cw1	Principles of credit, analysis of potential heat sources	1
Cw2	Calculation of primary energy demand and environmental impact	2
Cw3	Heat recovery in an industrial plant	2
Cw4	Balancing of absorption apparatuses in NH3-H2O chillers	2
Cw5	Balancing of absorption apparatuses in LiBr-H2O refrigerators	2
Cw6	Heat transfer in LiBr-H2O and NH3-H2O solutions	2
Cw7	Comprehensive calculations of sorption systems	2
Cw8	Credit	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture with the use of multimedia presentation
N2	Calculus exercises, discussion of solutions to tasks, use of computer program.
N3	Individual consultations

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_K01	Presentation of own calculations
P1	PEU_W01	Colloquium
P2	PEU_W02	Colloquium
P3	PEU_U01	Colloquium
P4	PEU_U02	Colloquium

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Herold K., Radermacher R., Sanford A. Klein – Absorption Chillers and Heat Pumps. CRC Press 1996
2	Ratlamwala I., Dincer T. A. H. – Integrated Absorption Refrigeration Systems, Springer International, 2016
3	Wang R., Wang L., Wu J. – Adsorption Refrigeration Technology: Theory and Application, Wiley, 2014
Secondary literaturę	
1	Nalepa B., Hałon T. – Recommendations for running a tandem of adsorption chillers connected in series and powered by low-temperature heat from district heating network. Energies. 2021, vol. 14, nr 16, art. 4791, s. 1-17.
2	Hałon T., Pelińska-Olko E., Szyc M., Zajączkowski B. – Predicting performance of a district heat powered adsorption chiller by means of an artificial neural network. Energies. 2019, vol. 12, nr 17, s. 1-11.

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

Imię i nazwisko:	Tomasz Hałon
E-mail:	tomasz.halon@pwr.edu.pl

Humanities course (eligible)

Faculty of	**Mechanical and Power Engineering**
Name in English	**Team management**
Name in Polish	**Team management**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**general**
Subject code	**W09-SM-W08HA3**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	75				
Form of crediting	Crediting				
For group of courses mark final course with (X)					
Number of ECTS points	3				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,28				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Not aplicaable

SUBJECT OBJECTIVES

C1	Gain knowledge of psychological models of teamwork, group dynamics and mechanisms determining their effectiveness.
C2	Gain the ability to diagnose and solve problems in the area of creating, leading and motivating teams.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Understands the nature and importance of the influence of psychological processes on the functioning of groups and teams.
PEU_W02	Has basic knowledge of the mechanisms that determine the formation of effective teams.
relating to skills:	
PEU_U01	Able to assume the role of a team leader.
PEU_U02	Can diagnose the group roles of individual team members.
relating to social competences:	
PEU_K01	Can identify problems in the functioning of groups and teams.
PEU_K02	Can predict the effects of groups (e.g., task and project groups) on the organization.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Principles of organization and conditions for passing classes. Psychological bases of functioning of teams in organizations.	2
Wy2	Basic orientations and motives of human behavior.	2
Wy3	Social perception and categorization processes.	2
Wy4	Group dynamics, team formation process, goals, norms, commitment, team identity.	2
Wy5	Characteristics of teams - group and team cohesion, motivation, and commitment.	2
Wy6	Psychological determinants of teamwork. Groupthink syndrome.	2
Wy7	Mechanisms of power and team leadership.	2
Wy8-9	Social influence mechanisms in teams.	2
Wy10	Managing creativity and innovation in a team.	2
Wy11	Negative phenomena in teamwork: stress, professional burnout - and ways to counteract them.	2
Wy12	Negative behaviors of team members: aggressive behaviors, counterproductive and deviant behaviors - and ways to counter them.	2
Wy13	Conflicts in teams and ways to resolve them.	2
Wy14	Team communication processes.	2
Wy15	Examples of effective and ineffective functioning of teams with consideration of the energy industry. Summary of the class.	2
Total hours		30

TEACHING TOOLS USED	
N1	Lecture using presentations and other multimedia tools
N2	Moderated discussion
N3	Case studies
N4	Individual assignments

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01-W02, PEU_K01-K02	Individual assessment for activity during lectures
F2	PEU_W01-W02, PEU_U01-U02	Credit test of knowledge
P1		C=1/3F1+2/3F2

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Rożnowski, B., Fortuna, P. (2020). *Psychologia biznesu.* Warszawa: Wydawnictwo Naukowe PWN.
2	Zawadzka, A.M. red. (2022). *Psychologia zarządzania w organizacji*. Warszawa: Wydawnictwo Naukowe PWN.
3	Wojciszke, B. (2022). *Psychologia społeczna. Wydanie 3.* Warszawa: Scholar
4	Cialdini, R. (2023). *Wywieranie wpływu na ludzi. Teoria i praktyka*. Gdańsk: GWP.
Secondary literature	
1	Duhigg Ch. (2016). *Mądrzej, szybciej, lepiej*. Warszawa: PWN.
2	Lencioni P. (2016). *Pięć dysfunkcji pracy zespołowej.* Gdańsk: GWP.
3	Brown, R. (2006). *Procesy grupowe. Dynamika wewnątrzgrupowa i międzygrupowa.* Gdańsk: GWP.

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

Imię i nazwisko:	Dr Anna Borkowska	
E-mail:	anna.borkowska@pwr.edu.pl	

Thermodynamic analysis of energy processes

Faculty of	**Mechanical and Power Engineering**
Name in English	**Thermodynamic analysis of energy processes**
Name in Polish	**Termodynamiczna analiza procesów energetycznych**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2348**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	25	25			
Form of crediting	Zaliczenie	Zaliczenie			
For group of courses mark final course with (X)					
Number of ECTS points	1	1			
including number of ECTS points for practical (P) classes		1			
including number of ECTS points for direct teacher-student contact (BU) classes	0,68	0,68			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Competence in the basics of thermodynamics, heat and mass transfer.

SUBJECT OBJECTIVES

C1	to familiarize students with the tools to optimize energy processes
C2	to acquaint students with the methods of calculating exergy and entropy

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	familiar with the methods of optimizing energy processes and devices
PEU_W02	knows the principles of the exergy and entropy analysis of energy processes
relating to skills:	
PEU_U01	can perform the entropy and exergy balance of different systems
PEU_U02	can perform the basic optimization of energy devices and processes

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Lec1	Energy analysis of processes and devices.	2
Lec2	Entropy generation. Entropy balance of the system.	2
Lec3	The concept of exergy as a work potential. Exergy destruction.	2

Lec4	Exergy balance of the system.	2
Lec5	Thermodynamic analysis of processes and devices in terms of II Law.	5
Lec6	The final test	2
Total hours		15

classes		Number of hours
Cl1	Energy balance and performance of different systems.	1
Cl2	Entropy balance.	2
Cl3	Exergy. Irreversibility. Second-law efficiency.	2
Cl4	Exergy analysis of closed systems	2
Cl5	Exergy analysis of control volumes	2
Cl6	Second-law analysis of complex systems.	4
Cl7	The final test	2
Total hours		

TEACHING TOOLS USED	
N1	Traditional lecture with multimedia presentation
N2	Solving problems on the whiteboard during classes.
N3	Computational programs
N4	Thermodynamic property calculators
N5	Consultation hours

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01, PEU_W02	Test (Lecture)
C2	PEU_U01, PEU_U02	Test (Classes)

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Yunus Cengel, Michael Boles, Thermodynamics: An Engineering Approach, 8th Edition, 2020
2	Yunus Cengel, Heat Transfer: A Practical Approach, 2nd Edition, 2002
3	Ibrahim Dincer, Marc A. Rosen, Exergy, 3rd edition 2020
Secondary literature	
1	Truls Gundersen, Introduction to Exergy and Energy Quality, Energy and Process Engineering, 2009
2	Jan Szargut, Egzergia: Poradnik obliczania i stosowania, Gliwice, 2007 (in Polish)
3	Wojciech Stanek, Analiza egzergetyczna w teorii I praktyce, Gliwice 20016 (in Polish)

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

Imię i nazwisko:	Adam Ruziewicz
E-mail:	adam.ruziewicz@pwr.edu.pl

Thermonuclear power generation

Faculty of	**Mechanical and Power Engineering**
Name in English	**Thermonuclear power generation**
Name in Polish	**Energetyka termojądrowa**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2357**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	25				
Form of crediting	Zaliczenie				
For group of courses mark final course with (X)					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	0,68				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Fundamentals of thermodynamics

SUBJECT OBJECTIVES

C1	Acquiring knowledge of the basics of nuclear physics, nuclear fusion and plasma physics
C2	Getting to know the various methods of controlled nuclear fusion
C3	Getting to know the results of the most important nuclear fusion experiments and applied engineering solutions

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Knowledge and understanding of the basics of nuclear fusion
PEU_W02	Familiarization with modern technologies of controlled nuclear fusion and the challenges associated with it
relating to skills:	
PEU_U01	
relating to social competences:	
PEU_K01	

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to nuclear physics: binding energy, basic fusion reactions.	2
Wy2	Basics of nuclear fusion, cross-section of the atom, Coulomb potential, tunnel effect on the example of the Schrödinger equation, Lawson's criterion.	2
Wy3-4	Methods of controlling plasma. Fusion reactors using a magnetic trap (Tokamak, Stellarator); Inertial reaktors. Usage of a laser to perform controlled fusion.	4
Wy5	Discussion of selected experiments: ASDEX, JET, WEST, Wendelstein 7-X, NIF. Plasma heating technologies, plasma dynamics and related phenomena.	4
Wy6	ITER reactor: main engineering challenges, superconducting magnets, cryogenic cooling. Prospects for building a power plant based on a thermonuclear reactor.	2
Wy7	Final test	1
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture using multimedia tools
N2	Consultations

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P1	PEU_W01, PEU_W02	Final test

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Kenro Miyamoto, Fundamentals of Plasma Physics and Controlled Fusion, NIFS-PROC-48 by National Institute of Fusion Science (NIFS) in Tokio.
2	B.K.Hodge, Alternative Energy Systems and Applications, John Wiley and Sons, 2009
3	G. Neilson, Magnetic Fusion Energy: From Experiments to Power Plants, Woodhead Publishing
Secondary literaturę	
1	Steven Van Sciver, Hellium Cryogenics, Springer
2	R.P.Feynman, R.B.Leighton, M.Sands, „ The Feynmann Lecture of Physics”

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

Imię i nazwisko:	prof. dr hab. inż. Maciej Chorowski
E-mail:	maciej.chorowski@pwr.edu.pl

Vapor-compression refrigeration systems

Wydział	**Mechaniczno-Energetyczny**
Nazwa w języku polskim	**Vapor-compression refrigeration systems**
Nazwa w języku angielskim	**Sprężarkowe systemy ziębnicze**
Kierunek studiów	**Energetyka**
Specjalność	**-**
Stopień	**I stopień**
Forma	**stacjonarna**
Rodzaj przedmiotu	**wybieralny**
Kod przedmiotu	**W09ENG-SM2363**
Grupa kursów	**NIE**

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	30		15		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	75		25		
Forma zaliczenia	Zaliczenie		Zaliczenie		
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	3		1		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			1		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	1,44		0,76		

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1.	Fundamental knowledge of thermodynamics, fluid mechanics and heat transfer.
2.	Knowledge of technical drawing and construction rules
3.	Ability to construct using graphic programs

CELE PRZEDMIOTU

C1	Transfer of basic knowledge, taking into account the application aspects of compressor refrigeration
C2	Transfer of knowledge regarding the calculation of heat exchangers and the selection of fittings and refrigeration automation.
C3	To develop skills in qualitative understanding, interpretation and quantitative analysis - based on dependencies describing cold cycles
C4	Developing students' skills to characterize processes in refrigeration equipment

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

Z zakresu wiedzy:	
PEU_W01	knows the basics of cooling system implementation and the differences between theoretical and actual cooling system.
PEU_W02	knows the mathematical model describing heat exchangers and principles of fitting selection
PEU_W03	have knowledge of the design of refrigeration compressor installations
Z zakresu umiejętności:	

PEU_U01	can determine the basic parameters of the refrigeration cycle and indicate the differences between the theoretical and actual refrigeration cycle.
PEU_U02	can conclude from the measurements of refrigeration plant operating parameters

TREŚCI PROGRAMOWE

Forma zajęć - wykład		Liczba godzin
Wy1	Refrigeration industry history and construction of the lgp-h chart. Natural methods of achieving the cooling effect	2
Wy2	Determining the basic parameters characterizing the cooling cycle. The theoretical and real refrigeration cycle and its representation on lg p -h.	2
Wy3	Self-regulation of the cooling cycle. The problems caused by self-regulation effects	2
Wy4	Opportunities to ensure a higher COP	2
Wy5	Division of refrigeration compressors, construction, principle of operation, mathematical model.	2
Wy6	Oil function in the refrigeration system. Oil selection. Mathematical model of cooling pipeline diameters.	2
Wy7	Rules of construction of the refrigeration system discharge line	2
Wy8	Rules of construction of a liquid refrigeration plant line.	2
Wy9	Condensers in compressor refrigeration installations - Mathematical model Evaporators in refrigeration installations - Mathematical model	2
Wy10	Condensation pressure control	2
Wy11	Rules of construction of compressor rack systems, capacity control of cooling plants	2
Wy12	Rules of construction of the refrigeration suction line. Parallel connecting of evaporators.	2
Wy13	Expansion elements in the refrigeration system	2
Wy14	Heat recovery from refrigeration installations. Mathematical model	2
Wy15	Colloquium	2
Suma godzin		30

Forma zajęć - laboratorium		Liczba godzin
La1	Safety regulations in laboratory classroom	1
La2	Getting a chilling effect with eutectic mixtures	2
La3	Measurements of work parameters of the household refrigerator and it's representation of its refrigeration cycle together with basic calculations of cycle. Cold room balance.	2
La4	Self-regulation effect on the high pressure side of the system and it's influence on COP of the cycle	2
La5	Self-regulation effect on the low pressure side of the system and it's influence on COP of the cycle	2
La6	Calculation of the condenser performance based on measurements, Calculation of the air cooler performance based on measurements	2
La7	Refrigerant load of the refrogeration plant and it's influence on COP , Operation of the thermostatic expansion valve, it's regulation and influence on COP.	2
La8	Corrective and supplementary classes	
Suma godzin		15

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1	Lecture with presentation
N2	Laboratory – discussion of problems
N3	Self-study – reading of supplementary materials.
N4	Office hours.

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ

Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
P1	PEU-W01, PEU-W02, PEU-W03	Mark of the colloquium
F1	PEU_U01, PEU_U02	Reports from laboratory classes

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

Literatura podstawowa	
1	Rex Miller, Mark R. Miller, Air conditioning and refrigeration McGraw-Hill Professional Publishing,2006
2	Risto Ciconkov Refrigeration - Solved examples, "St Kiril & Metodij" Faculty of Mechanical Engineering. Po. Box 464. 1000 Skopie Macedonia
3	Handbook: refrigeration, American Society of Heating, Refrigerating and Air-Conditioning ASHRAE 2006
4	Wilbert F. Stoecker - Industrial refrigeration handbook McGraw-Hill 1998
Literatura uzupełniająca	
1	Technical bulletins of manufacturers of the refrigeration equipment

OPIEKUN PRZEDMIOTU

Imię i nazwisko:	Stefan Reszewski
E-mail:	stefan.reszewski@pwr.edu.pl

Water power engineering

Faculty of	**Mechanical and Power Engineering**
Name in English	**Water power engineering**
Name in Polish	**Energetyka wodna**
Main field of study	**Water Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2354**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15	15	
Number of hours of total student workload (CNPS)	25		25	25	
Form of crediting	Zaliczenie		Zaliczenie	Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	1		1	1	
including number of ECTS points for practical (P) classes			1	1	
including number of ECTS points for direct teacher-student contact (BU) classes	0,68		0,68	0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge of issues related to solid mechanics and fluid mechanics.
2.	Basic knowledge of turbomachinery.
3.	Ability to use spreadsheets and CAD programs.

SUBJECT OBJECTIVES

C1	Students will learn various methods of harnessing water resources for renewable energy purposes, which will include the process of energy accumulation.
C2	To provide students with the importance of hydropower for the electricity system, ecology and economy.
C3	Students will learn the types and principles of operation of water turbines.
C4	To provide students with the construction of hydroelectric power.
C5	Developing skills identification and assessment of water energy resources.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Understands concepts of water management, has knowledge about the possibilities of the use of the energy contained in the water.
PEU_W02	Have knowledge of how the select turbine type, their numbers, arrangement and generators
PEU_W03	Understands the concept: installed parameters, draft tube, halfspiral, open chamber,
PEU_W04	Have knowledge of the calculation and operations of different types of hydro power plants
relating to skills:	

PEU_U01	is able to: conduct the investigation of water turbines.
PEU_U02	is able to: assess the hydro potential of the river and select installation parameters of HPP.
PEU_U03	is able to: calculate energy potential for different types of HPP
PEU_U04	is able to: select turbines by means of peak performance characteristics.

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to the lecture. Water as a renewable energy and a base of economy operation.	2
Wy2	Basic information about hydrology. Hydrographs, types of rivers, energy concentration.	2
Wy3	Run of river hydro power plants - parameters determination.	2
Wy4	Parameters determination of the hydro - plants working with daily and weekly controlled reservoir	2
Wy5	Theory of water turbines. Specific speed. Types of water turbines. Hydraulic similarity.	2
Wy6	Water turbines operating parameters and rules of rational construction. Turbine characteristics.	2
Wy7	Basic of water-turbine and electric generator selection.	2
Wy8	Building flow elements of hydro - plants. Turbine auxiliary equipment.	1
Suma godzin		15

laboratory		Number of hours
La1	Basic information and introduction to the laboratory.	2
La2	Introduction to the subject of water turbine research.	2
La3	Determination of the operating characteristics of the Francis turbine	2
La4	Energy study of a pump in turbine operation.	3
La5	Determination of the operational characteristics of the Pelton turbine.	3
La6	Determination of the characteristics of the universal Francis turbine.	3
Suma godzin		15

project		Number of hours
Pr1	Basic information and introduction to the project, types of hydropower plants, design point (credit conditions of the course, input data).	1
Pr2	Compositions of hydropower plants and water turbines. Run-of-the-river hydroelectricity scheme.	2
Pr3	Assessment of the hydropotential of the selected river.	2
Pr4	Determination of numbers and size of water turbines and hydro generators.	2
Pr5	Turbine selection based on characteristic curves.	2
Pr6	Cavitation calculation in water turbines.	2
Pr7	Determination of the basic dimension of the Kaplan turbine, spiral case and draft tube.	2
Pr8	Designing the offer draft of a hydropower plant.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Traditional lecture using slides, animation and presentation software.
N2	Laboratory.
N3	Project: discuss the algorithms and methods of selection elements of the plant.
N4	Own work.
N5	Consultation.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01 - PEU_W04	Test.
F1-F3	PEU_U03 - PEU_U04	Reports.
C2=(F1-F5)/3		
F1-F5	PEU_U01	Reports.
C3=(F1-F5)/5		

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	H. Moazam, S. Hamza, J. Umer „Hydropower with Kaplan hydro turbine : a theory and approach to kaplan turbine design (future of micro hydro turbines)", LAP Lambert Academic Publishing, 2011.
2	S. Michałowski, J. Plutecki „Energetyka wodna", WNT, Warszawa 1975.
3	P. Stawski, at All „Water Power Plants", Wroclaw 2011.
4	T. Jiandong, Z. Naibo, W. Xianhuan, H. Jing, d. Huishen, „Mini Hydropower", John Wiley & Sons, New York 1996.
5	F. R. Frsund, „Hydropower economics", Springer, New York 2007.
6	J. Fritz, „Small and mini hydropower systems : resource assessment and project feasibility", McGraw-Hill Book Co., New York 1984.
7	ESHA „Guide on How to Develop a Small Hydropower Plant" (European Small Hydropower Association), 2004.
Secondary literature	
1	International Water Power and Dam Construction - Magazine
2	Carrasco F., „Introduction to hydropower", The Englisch Press 2011
3	PN-EN 60041:1999 Badania odbiorcze przeprowadzane w warunkach eksploatacyjnych celem określenia hydraulicznych parametrów ruchowych turbin wodnych, pomp zasobnikowych i turbin odwracalnych.

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

Imię i nazwisko:	Przemysław Szulc
E-mail:	przemyslaw.szulc@pwr.edu.pl

Wind power plants

Faculty of	**Mechanical and Power Engineering**
Name in English	**Wind power plants**
Name in Polish	**Energetyka wiatrowa**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2355**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	25			50	
Form of crediting	Zaliczenie			Zaliczenie	
For group of courses mark final course with (X)					
Number of ECTS points	1			2	
including number of ECTS points for practical (P) classes				2	
including number of ECTS points for direct teacher-student contact (BU) classes	0,68			0,76	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Fundamentals of fluid mechanics

SUBJECT OBJECTIVES

C1	Familiarization of students with principles of operation and construction of wind turbines
C2	Introduction to wind and terrain characteristics and their influence of wind turbine design and operation
C3	Introduction to blade element theory and aerodynamics of wind turbine
C4	Familiarization of students with economic and ecological aspects of wind turbines
C5	Providing basic knowledge about wind turbine farms and skills to select an optimal location for wind turbines

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	knows and understands principles of wind turbine design, construction and operation
PEU_W02	knows and understands fundamental theories related to wind turbine operation
relating to skills:	
PEU_U01	Wind turbine blade design: determination of the range of Reynolds numbers of the blade, calculation of an optimal twist angle of the blade.
PEU_U02	Using Blade Element Method: calculation of the turbine power and aerodynamic forces, aerodynamic analysis of the designed blade.

PEU_U03	Determination of an optimal location for the designed wind turbine, calculation of an annual production of the wind turbine based on the Weibull distribution.
relating to social competences:	
PEU_K01	

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Linear momentum theory for wind turbines, actuation disc model, Betz limit and theoretical efficiency of wind turbine.	2
Wy2	Angular momentum theory for wind turbine, introduction of tip speed ratio parameter and angular induction factor	2
Wy3	Blade element method	2
Wy4	Introduction to wind physics and mathematical description of main wind parameters related to wind power plants. Selection of a most optimal location for a wind turbine	2
Wy5	Control and regulation of wind turbine performance, passive and active control and regulation	2
Wy6	Vertical axis wind turbines	2
Wy7	Wind farms and mutual interaction of wind turbines. Final test.	3
Suma godzin		15

project		Number of hours
Pr1	Discussion of the project goal and scope.	1
Pr2	Introduction to Qblade software used for wind turbine design. Preliminary assumptions of individual projects: rated power, rated wind velocity, rpm, tip speed ratio.	2
Pr3	Design of wind turbine blade: determination of basic wind turbine rotor and blades parameters; Selection of aerodynamic airfoils.	2
Pr4	Wind turbine blade design: determination of the range of Reynolds numbers of the blade, calculation of an optimal twist angle of blades.	2
Pr5	Using Blade Element Method: calculation of aerodynamic forces, moments, power efficiency; Aerodynamic analysis of the designed blade.	2
Pr6	Determination of an optimal location for the designed wind turbine, calculation of annual electricity production of the wind turbine based on the Weibull distribution.	2
Pr7	Selection of other turbine components and basic stress and load analysis.	2
Pr8	Presentation of the project.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Lectures using multimedia presentation.
N2	Students own work - independent studies and preparation for final test.
N3	QBlade software
N4	Detailed list of things to do for the project with explanations.
N5	Partial presentations during each project class to show and discuss progress in the project

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01, PEU_W02	Final test

C2	PEU_U01 -- PEU_U03	Grades for completed project stages

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	Burton T.: Wind Energy Handbook 3rd edition, Wiley, 2021
2	Manwell J.: Wind Energy Explained: Theory, Design and Application, Wiley, 2009
3	Burton T.: Wind Energy Handbook 2nd edition, Wiley, 2011
4	Malecha Z.: Aerodynamika turbin wiatrowych. Wybrane aspekty, Oficyna PWr, 2023
Secondary literaturę	
1	Ackermann T.: Wind Power in Power Systems, Wiley, 2005

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

Imię i nazwisko:	Ziemowit Malecha
E-mail:	Ziemowit.malecha@pwr.edu.pl