STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Fluid Mechanics II**			Code **1010135211010130182**
Field of study **Enviromental Engineering Extramural Second-**	Profile of study (general academic, practical) **(brak)**		Year /Semester **1 / 1**
Elective path/specialty **Heating, Air Conditioning and And**	Subject offered in: **Polish**		Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **part-time**		
No. of hours Lecture: **20** Classes: **10** Laboratory: **10** Project/seminars: **-**			No. of credits **5**
Status of the course in the study program (Basic, major, other) **(brak)**	(university-wide, from another field) **(brak)**		
Education areas and fields of science and art **technical sciences** **Technical sciences**			ECTS distribution (number and %) **5 100%** **5 100%**

Responsible for subject / lecturer:

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Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Mathematics: differential and integral calculus, ordinary and partial differential equations, combinatorics and calculus of probability, basic numerical methods at level 6 of KRK Classical physics at 5 KRK level, fluid mechanics at 6 level of KRK
2	**Skills**	Mathematics: the use of differential and integral calculus to calculate physical phenomena, solving ordinary differential equations and simple partial differential equations, solving complex differential equations by means of numerical methods Fluid Mechanics: solving fluid statics, kinematics and dynamics problems and making fluid mechanics measurements at level 6 of KRK
3	**Social competencies**	Awareness of the need of constantly update and permanently supplement knowledge and skills

Assumptions and objectives of the course:

Extending and deepening the knowledge and skills in fluid mechanics required to solve complex fluid flow problems appear both in built and natural environment

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

Knowledge:

1. The student has structured and theoretically extended knowledge of the kinematics of turbomachinery blading systems - [K2_W03, K2_W04, K2_W07]

2. The student knows the basic laws and equations of compressible fluid flows - [K2_W03, K2_W04, K2_W07]

3. The student knows and understands the origin and structure of differential equations expressing conservation of mass, momentum and energy in fluid mechanics (computational fluid dynamics equations) - [K2_W03, K2_W04, K2_W07]

4. The student has expanded and theoretically established knowledge necessary for the simplifying the equations of conservation of mass momentum and energy in fluid mechanics and understands the consequences of these simplifications - [K2_W03, K2_W04, K2_W07]

5. The student knows the phenomena responsible for the loss of energy in fluid flows, and has in-depth knowledge of the ways to reduce these losses - [K2_W03, K2_W04, K2_W07]

6. Students understand the phenomenon of turbulence, and knows the mathematical basis of its modeling - [K2_W03, K2_W04, K2_W07]

7. The student knows foundations of computer fluid dynamics (CFD), is aware both of advantages and limitations of CFD methods, knows and understands the need to verify and validate the results of CFD calculations - [K2_W03, K2_W04, K2_W07]

8. The student knows classification of non-Newtonian fluids and understands foundations of mathematical description of non-Newtonian fluids flows - [K2_W03, K2_W04, K2_W07]

Skills:

1. Student is able to introduce simplification in differential equations describing complex fluid flows and predict consequences of the simplifications - [K2_U01, K2_U18]

2. Student can calculate theoretically flow characteristics of complex engineering systems both for incompressible and compressible fluids - [K2_U01, K2_U18]

3. Student is able to determine by means of experimental methods the flow characteristics of pumps, fans, control valves and fittings - [K2_U01, K2_U08,]

4. The student has the ability to examine using LDA technique the structures of complex fluid flows - [K2_U01, K2_U08,]

5. The student is able to determine experimentally the flow characteristics of complex engineering systems - [K2_U01, K2_U08,]

Social competencies:

1. The student understands the need for teamwork in solving theoretical and practical problems - [K2_K03]

2. The student is aware of the need to evaluate the uncertainty of measurement and calculation results - [K2_K05]

3. The student sees the need for systematic increasing his professional skills and competences - [K2_K01]

Assessment methods of study outcomes

Lectures

?Final exam consists of two parts. Part 1: knowledge test (4 questions to answer), Part. 2: test of skills (2 problems to solve),

?Continuous assessment of the students during lectures (rewarding activity of the students).

Tutorials

?One short written test in the middle of semester and one written final test at the end of semester

?Continuous assessment of the students (rewarding students activity).

Laboratory exercises:

?Assessment of individual prepared reports and their oral presentation

?Continuous assessment of the students during laboratory exercises

Course description

Kinematics of turbomachinery blading systems. Velocity triangles of blading systems. Basic equation of turbomachinery. Compressible fluid flows. Adiabatic gas flow in the duct with constant cross-section

Static, dynamic and total enthalpy. Critical Mach number. Critical gas pressure and density.

The differential equations of mass, momentum and energy conservation. The general and simplified forms of the conservation equations. Introduction to turbulence. Average velocity, velocity fluctuations. Scale of turbulence. Turbulence intensity. Turbulent viscosity. Kinetic energy of turbulence. Dissipation of turbulence kinetic energy. Selected models of turbulence. Reynolds equations (RANS). Basics of non-Newtonian fluid mechanics. Rheological models. Wael-Ostwald formula. Generalized Reynolds number. Pressure losses calculation for non-Newtonian fluids flows.

Basic bibliography:

1. Mitosek M., Mechanika płynów w inżynierii i ochronie środowiska. Warszawa, PWN 2001
2. Orzechowski Z., Prywer J., Zarzycki R., Mechanika płynów w inżynierii środowiska. Wyd. 2 zmienione. Warszawa, WNT 2001
3. Jeżowiecka-Kabsch K., Szewczyk H., Mechanika płynów. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2001
4. Mitosek M., Matlak M., Kodura A., Zbiór zadań z hydrauliki dla inżynierii i ochrony środowiska. Oficyna wydawnicza Politechniki Warszawskiej, Warszawa 2004
5. Orzechowski Z., Prywer J., Zarzycki R., Zadania z mechanika płynów w inżynierii środowiska. Warszawa, WNT 2001
6. Bogusławski L. (Red.), Ćwiczenia laboratoryjne z mechaniki płynów. Wydawnictwo Politechniki Poznańskiej, Poznań 1999
7. Niełacny M., Ćwiczenia laboratoryjne z mechaniki płynów. Wydawnictwo Politechniki Poznańskiej, Poznań 1996

Additional bibliography:

1. Munson B.R., Young D.F., Okiishi T.H., Fundamentals of Fluid Mechanics (4rd. Ed.). John Wiley and Sons Inc., New York 2002
2. White F.M., Fluid Mechanics. McGrawHill Book Company. 5th Int. Ed. Boston 2003

Result of average student's workload

Activity	Time (working hours)
1. Participation in lectures	30
2. Participation in tutorials	15
3. Participation in laboratory exercises	15
4. Preparation for the laboratory exercises	9
5. Preparing (at home) reports of the laboratory exercises	8
6. Participation in consultations related to the lectures, tutorials and laboratory exercises	3
7. Preparation for the final test of tutorials	10
8. Preparation for the exam and the present at the exam	15

Student’s workload

Source of workload	hours	ECTS
Total workload	105	5
Contact hours	63	2
Practical activities	15	1