course title:		
ADVANCED FLUID MECHANICS **Zaawansowana mechanika płynów**		
field of study: **Mechanical Engineering**	type of studies: **regular**	course code: **S4_2**
specialization: **Energy engineering**	level: **MSc**	year: **I** semester: **I**
types of classes: **lecture, laboratory**	hours/week: **2Lec^{E}, 2Lab**	No of ECTS credits: **6**

COURSE DESCRIPTION

COURSE TARGETS

C1. Provide theory of potential flows
C2. Provide theory of boundary layer.
C3. To acquire capabilities to perform experimental-numerical analysis of the flow field.

ENTRY REQUIREMENTS IN TERMS OF KNOWLEDGE, CAPABILITIES AND COMPETENCES

1. Fundamentals of mechanics, thermodynamics and fluid mechanics.
2. Statistics and error estimation.
3. Safety rules during the use of laboratory equipment.
4. Capability of using source literature.
5. Capability of individual work and collaboration in a group.
6. Data analysis and presentation of results.

EFFECTS OF TEACHING

EK1. Knowledge on elementary potential flows
EK2. Knowledge on superposition of elementary flows
EK3. Knowledge on lift generation in flows around airfoils
EK4. Knowledge on laminar-turbulent transition
EK5. Knowledge on the structure of turbulent boundary layer
EK6. Knowledge on boundary layer separation and its consequences to flow quality
EK7. Ability to predict the flow pattern and the form drag coefficient

COURSE CONTENT

LECTURE	hours
W1-6 - Elements of potential flow theory, velocity potential, the stream function and flow net, elementary flows (uniform flow, stagnation flow, two-dimensional source, potential vortex, double source and a doublet)	**6**
W7-10 - Superposition of elementary flows - a sample solution, complex potential of two-dimensional irrotational flows, complex potential applied to elementary flows (uniform flow, two dimensional source, two-dimensional potential vortex, the double source and a dipole),	**4**
W11-15 - Potential flow around a cylinder, potential flow around a cylinder with circulation, flows past streamlined bodies.	**5**
W16-17 - Boundary layer (BL), definition, properties, characteristic parameters. BL development on a flat surface, laminar-turbulent transition. Laminar BL, velocity distribution, frictional drag force and its coefficient.	**2**
W18-19 - Turbulent BL, power law of velocity profile, frictional drag force and its coefficient.	**2**
W20-21 - Momentum transfer in turbulent BL, logarithmic velocity profile, viscous sublayer, surface roughness and its influence on frictional drag force coefficient.	**2**
W22 - Multi-zonal model of turbulent BL	**1**
W23-24 - Form drag, streamlined bodies, BL separation, bluff bodies, wakes, drag force coefficient.	**2**
W25-27 - Flow evolution upon an adverse pressure gradient, BL separation. Flow around the cylinder. Sub- and supercritical flow pattern, drag crisis, drag force coefficient versus Reynolds number.	**3**
W28-29 - Control of BL separation, suction, injection.	**2**
W30 - Blasius equation and its solution for the flow in a laminar BL	**1**
LABORATORY	**hours**
L 1-4 - Numerical analysis of elementary potential flows	**4**
L 5-8 - Superposition of elementary potential flows	**4**
L 9-10 - Determination of integral parameters of boundary layer	**2**
L 11-14 - Flow modelling in a laminar boundary layer	**4**
L 15-18 - Determination of multilayer structure of turbulent boundary layer	**4**
L 19-22 - Experimental investigation of a drag force coefficient of a bluff bodies	**4**
L 23-26 - Numerical simulation of a boundary layer separation	**4**
L 27-30 - Experimental analysis of a von Karman vortex path	**4**

TEACHING TOOLS

1 - lecture with the use of multimedia presentations
2 - experimental stands equipped with measuring instrumentation
3 - computer laboratory, software for fluid flow simulation
4 - instructions to laboratory exercises

STUDENT LOADING

activity	hours
contact hours with teachers reading preparation to lab exercises writing reports preparation to exam	30Lec + 30Lab → 60h 15 h 15 h 30 h 30 h
Suma	**∑ 150 h**

SOURCE LITERATURE

1.	R.J. Goldstein: Fluid mechanics measurements. Taylor & Francis, 1996
2.	Durst F.: Fluid Mechanics. An introduction to the theory of fluid flows. Springer-Verlag, Berlin, 2008
3.	J.W. Elsner, S. Drobniak: Metrologia turbulencji przepływów. Ossolineum, Wrocław, 1995
4.	Schlichting H., Gersten K.: Boundary layer theory. Springer, 2000
5.	Mathieu J., Scott J. : An introduction to turbulent flows. Cambridge University Press, 2000
6.	Kundu P., Cohen I.: Fluid mechanics. Academic Press, 2010
7.	Pope S.: Turbulent flows. Cambridge University Press, 2000
8.	Drobniak S., Elements of Potential Flow Theory

TEACHERS

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