COURSE SPECIFICATION

Course code	full-time programme:	**M#2-S1-ME-406**
	part-time programme:	
Course title in Polish	**Mechanika Płynów**	
Course title in English	**Fluid Mechanics**	
Valid from (academic year)	**2024/2025**	

GENERAL INFORMATION

Programme of study	**MECHANICAL ENGINEERING**
Level of qualification	**first-cycle**
Type of education	**academic**
Mode of study	**full-time programme**
Specialism	**all**
Department responsible	**Department of Mechanics and Heat Transfer**
Course leader	**Prof. dr hab. inż. Magdalena Piasecka**
Approved by	**dr hab. Jakub Takosoglu, prof. PŚk, Dean of the Faculty of Mechatronics and Mechanical Engineering**

COURSE OVERVIEW

Course type		**programme-specific**
Course status		**compulsory**
Language of instruction		**English**
Semester of delivery	full-time programme	**Semester IV**
	part-time programme	
Pre-requisites		
Examination required (YES/NO)		**YES**
ECTS value		**4**

Mode of instruction		**lecture**	**class**	**laboratory**	**project**	**seminar**
No. of hours per semester	full-time programme	**15**	**15**	**15**		
	part-time programme					

LEARNING OUTCOMES

Category of outcome	Outcome code	Course learning outcomes	Corresponding programme outcome code
Knowledge	W01	The student has organised knowledge in the field of fluid properties, including a familiarity with basic physical quantities and their units. The student is aware of the differences between ideal and real fluids, as well as the types of refrigerants and greenhouse gases (especially fluorinated ones).	MiBM1_W02
	W02	The student possesses organised knowledge in the field of fluid statics, including familiarity with basic statics equations, recognition of pressure measurement devices, knowledge of hydrostatic pressure determination; understanding of Archimedes' principle; the student understands the differences between the absolute pressure vacuum and the gauge pressure and has knowledge of the relative equilibrium.	MiBM1_W02
	W03	The student understands fundamental terms and definitions related to fluid kinematics and has knowledge of the continuity equation.	MiBM1_W02
	W04	The student has organised knowledge in the field of fluid dynamics, including topics related to mass and volumetric flow rates. The student is familiar with the Bernoulli principle and its applications. The student distinguishes between laminar and turbulent flows and has knowledge of critical Reynolds numbers.	MiBM1_W02
	W05	The student has organised knowledge in the field of energy losses that occur during fluid flow and is familiar with methods for their determination. The student has knowledge about the flow of refrigerants in closed conduits and their impact on the ozone layer. The student understands the concept of the boundary layer, is aware of issues related to the flow of solid bodies through viscous fluids, and has basic knowledge related to the field of aerodynamics.	MiBM1_W02
	W06	The student has a basic knowledge on regulations related to fluorinated greenhouse gases, especially on restrictions and requirements established by EU directives, regulations, and national legislation.	MiBM1_W05
Skills	U01	The student has the ability to determine the density of a mixture characterised by the specified mass or volume fractions. The student is able to calculate changes in volume, viscosity, or fluid density when pressure and/or temperature change and to use the Clapeyron equation in gas-related tasks.	MiBM1_U12
	U02	The student has the ability to calculate the viscosity of the fluid through experimental measurements of shear stress as a function of shape deformation using a rotational viscometer.	MiBM1_U01 MiBM1_U12
	U03	The student is able to apply Pascal's principle, calculate the hydrostatic pressure in closed vessels, and use the equation of fluid equilibrium as well as the law of connected vessels.	MiBM1_U12

	U04	The student is capable of determining the free surface equation for relative equilibrium (rotational motion around a vertical axis), also experimentally.	MiBM1_U01 MiBM1_U12
	U05	The student is able to apply the Bernoulli principle to ideal and real fluid flow in a closed conduit. The student has the ability to determine energy losses during the flow of real fluid in a pipeline.	MiBM1_U01 MiBM1_U12
	U06	The student is able to determine critical Reynolds numbers through experimentation. The student has skills to determine typical characteristics of a flow machine - a pump, on the basis of experiment.	MiBM1_U01 MiBM1_U12
	U07	The student can interpret the requirements of regulations regarding fluorinated greenhouse gases.	MiBM1_U16
Competence	K01	The student is ready for a critical assessment of existing knowledge and the need to acquire new information both from literature and from experts in the field of mechanics and mechanical engineering.	MiBM1_K01
	K02	The student is aware of the environmental impact of fluid storage and transportation methods. The student also recognises the importance of greenhouse gases in the environment and the associated responsibilities.	MiBM1_K02
	K03	The student acknowledges the need for acquiring new information through independent supplementation and expansion of knowledge in the field of physical phenomena, measurement of physical quantities, particularly in fluid mechanics.	MiBM1_K05

COURSE CONTENT

Type of instruction lecture	Topics covered
lecture	The subject of fluid mechanics. Real and ideal fluids. Physical properties of fluids. Refrigerants and greenhouse gases, particularly fluorinated, and their impact on the ozone layer and environmental regulations. Forces acting on fluids. Statics of fluids. Basic equation of fluid statics. Pressure measurement. Gauge pressure, vacuum pressure and absolute pressure. Pascal's law. Manometers. Hydrostatic pressure on surfaces submerged in a fluid. Stevin's paradox. Connected vessels. Relative equilibrium in linear motion and rotating vessels. Archimedes' principle. Equilibrium of floating bodies. Static equilibrium of compressible fluids. Basics of fluid kinematic. Description of fluid motion. Continuity equation. Classification of flows. Steady flow. Fluid dynamics, Euler's equation of motion. Bernoulli principle. Applications of the Bernoulli principle. Bernoulli principle for real fluids. Dynamic equation of motion for a viscous fluid (Navier-Stokes equations). Flows in closed conduits (internal flow). Hagen-Poiseuille law. Laminar and turbulent flows. Critical Reynolds numbers. Energy losses by pipe friction and head losses. Flow similarity. Typical problems in hydraulic calculations. Flows in open channels. The concept of the boundary layer, flow over bodies (external flow). Scope of aerodynamics.

class	Solving problems in the scope covered by the lecture, namely: • Physical properties of fluids: mass, density, determination of fluid density for a given mass/volume fraction of a mixture; application of the Clapeyron equation to issues concerning ideal gases. • Physical characteristics of fluids: compressibility, expansibility, and viscosity. • Basic issues of fluid statics; thrust and hydrostatic pressure. • Law of connected vessels in fluid statics problems. • Mass/volume flow rate; continuity equation, Bernoulli principle in calculations regarding the flow of an ideal fluid. • Energy losses during the flow of a real fluid; Bernoulli principle in calculations regarding the flow of a real fluid in closed conduits. • Application of Bernoulli principle in issues during the flow of a real fluid - selected topics.
laboratory	Completion of 6 laboratory exercises as follows: • Measurement of tangential stresses in a liquid. • Relative equilibrium of liquids. • Flow visualization - critical Reynolds number. • Losses by pipe friction: determination of Darcy friction factor during the flow of water in the close loop. • Head losses: determination of the head loss factor for the sudden change of area • Determining of the characteristics of a selected flow machine (a pump). Additionally: • Familiarisation of students with principles of processing experimental data and error analysis; • Refrigerants and fluorinated greenhouse gases – issues related to leak tightness, F-gas training (scope, topics, requirements).

ASSESSMENT METHODS

Outcome code	Methods of assessment *(Mark with an X where applicable)*					
	Oral examination	Written examination	Test	Project	Report	Other
W01		X				
W02		X				
W03		X				
W04		X				
W05		X				
W06		X				
U01			X			
U02					X	
U03			X			
U04					X	
U05			X		X	
U06					X	
U07						X
K01					X	
K02						X
K03					X	

ASSESSMENT TYPE AND CRITERIA

Mode of instruction	Assessment type	Assessment criteria
lecture	examination assessment	The pass mark is a minimum of 50% for all the in-class tests.
class	non-examination assessment	The pass mark is a minimum of 50% for all the in-class tests.
laboratory	non-examination assessment	Approval of reports on individual laboratory activities. The final grade is the arithmetic mean of the test grades for each laboratory exercise.

OVERALL STUDENT WORKLOAD

ECTS weighting												
No.	Activity type	Student workload										Unit
		full-time programme					part-time programme					
1.	Scheduled contact hours	L	C	Lb	P	S	L	C	Lb	P	S	h
		15	15	15								
2.	Other contact hours (office hours, examination)	4	2	2								h
3.	**Total number of contact hours**	**53**										h
4.	**Number of ECTS credits for contact hours**	**2,1**										ECTS
5.	**Number of independent study hours**	**47**										h
6.	**Number of ECTS credits for independent study hours**	**1,9**										ECTS
7.	**Number of practical hours**	**67**										h
8.	**Number of ECTS credits for practical hours**	**2,7**										ECTS
9.	**Total study time**	**100**										h
10.	**ECTS credits for the course** *1 ECTS credit = 25-30 hours of study time*	**4**										ECTS

READING LIST

1. Nakayama Y., Boucher R.F.: Introduction to Fluid Mechanics, Butterworth Heinemann 2002.

2. Cengel Y. A., Cimbala J. M.: Fluid Mechanics. Fundamentals and Applications, McGraw-Hill Inc. 2014.

3. Munson B. R., Young D. F., Okiischi T. H., Huebsch W. W.: Fundamental of Fluid Mechanics, John Wiley & Sons Inc., 2009.

4. Regulation (EU) 2024/573 on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014 and Regulation (EU) 2024/590 on substances that deplete the ozone layer, and repealing Regulation (EC) No 1005/2009 (https://perma.cc/QS32-GEZT)

5. Laboratory of Fluid Mechanics- Instructions for each laboratory meeting.