Politechnika Krakowska im. Tadeusza Kościuszki

Karta przedmiotu

obowiązuje studentów rozpoczynających studia w roku akademickim 2022/2023

Wydział Mechaniczny

Kierunek studiów: Mechanika i Budowa Maszyn | Profil: Ogólnoakademicki

Forma sudiów: stacjonarne | Kod kierunku: M

Stopień studiów: I

Specjalności: Computational Mechanics (Mechanika obliczeniowa- w języku angielskim),Machine design (Konstrukcja maszyn- w języku angielskim)

1 Informacje o przedmiocie

Nazwa przedmiotu	Fluid mechanics
Nazwa przedmiotu w języku angielskim	Fluid mechanics
Kod przedmiotu	WM MIBM oIS B13 22/23
Kategoria przedmiotu	Przedmioty kierunkowe
Liczba punktów ECTS	5.00
Semestry	4

2 Rodzaj zajęć, liczba godzin w planie studiów

Semestr	Wykład	Ćwiczenia	Laboratorium	Laboratorium komputerowe	Projekt	Seminarium
4	15	30	15	0	0	0

3 Cele przedmiotu

Cel 1 To familiarize students with the basic macroscopic properties of fluids, the forces acting on the fluid element and the types of physical quantity fields.

Cel 2 To familiarize students with the method of formulating of fluid equilibrium differential equations and to develop the skills of integrating these equations. To familiarize students with the concept of hydrostatic

pressure and to develop the ability to calculate the forces of pressure on plain and curved areas.

Cel 3 To acquaint students with the elements of fluid kinematics, including the concepts of the path line of a fluid element, streamline, flow rate as well as the continuity equation and its special cases.

Cel 4 To acquaint students with the method of formulating: Euler's differential equations of motion of an ideal fluid, Bernoulli's integral, Bernoulli's equations for an ideal fluid and the continuity equation.

Cel 5 To acquaint students with the application of the Bernoulli equation in engineering approach to measure local velocity, to measure the flow rate by the use of stagnation flowmeters and to study the outflow of liquid from a reservoir through a small orifice.

Cel 6 To acquaint students with the laws governing the flow of real fluid in laminar and turbulent motion and to develop the ability to determine pressure losses during fluid flow in pipelines.

4 Wymagania wstępne w zakresie wiedzy, umiejętności i innych kompetencji

1 Knowledge of the basics of classical mechanics.

2 Knowledge of mathematical analysis, vector algebra and the basics of field theory.

5 Efekty kształcenia

EK1 Wiedza The student defines the basic properties of the fluid, types of forces acting on the fluid element, gives mathematical models for the description of the fluid, and defines and distinguishes between types of physical quantities.

EK2 Wiedza The student derives the Euler equilibrium equations, gives the conditions for integrating these equations, derives the dependencies for the pressure distribution in the area of the equilibrium liquid and derives the dependencies on the values of the pressure forces and the coordinates of the center of pressure on plain and curved wall areas.

EK3 Wiedza The student defines the concepts of fluid element path line, streamline, flow rate and also derives the continuity equation and its special cases.

EK4 Wiedza The student derives the Euler perfect fluid motion equations, gives the assumptions for the Bernoulli integral and derives the Bernoulli equation for the perfect fluid and gives its physical and geometrical interpretation.

EK5 Wiedza The student defines the concept of the Reynolds number, distinguishes between laminar and turbulent motion and derives dependencies for the velocity distribution, tangential stress distribution in a circular pipe and the Hagen-Poiseuille law, and gives its application in engineering practice.

EK6 Umiejętności The student integrates the Euler equilibrium equations, determines the pressure distribution in the area of the liquid in equilibrium, determines the thrust forces and the position of the center of pressure on plain and curved wall areas.

EK7 Umiejętności The student uses the Bernoulli equation for an perfect fluid in problems concerning the measurement of velocity and flow rate as well as the outflow of liquid from a tank through small orifice.

EK8 Umiejętności Student determines pressure losses due to internal friction and local obstacles and uses Bernoulli's equation for real fluid.

EK9 Kompetencje społeczne The student cooperates in a team and organizes its work, and also prepares reports and reports on the team's work.

6 Treści programowe

Ćwiczenia		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
C1	Fluid statics: 1) Integration of Euler's equilibrium equations. Relative and absolute equilibrium in the potential field of mass forces. 2) Fluid pressure on plain and curved wall surfaces. Buoyancy. 3) Stability of floating of bodies completely or partially submerged in a liquid.	14
C2	Ideal fluid dynamics: 1) One-dimensional ideal fluid flows. 2) Applications of the Bernoulli equation. 3) The flow of liquid from the tanks through small holes.	8
C3	Real fluid dynamics: 1) Real fluid flow in closed conduits. 2) Pressure losses due to internal friction and local obstacles.	8

Laboratorium		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
L1	Fluid statics: 1) Measurement of liquid viscosity.	2
L2	Ideal fluid dynamics: 1) Liquid outflow through small orificel. 2) Measure the fluid flow rate.	4
L3	Real fluid dynamics: 1) Classic Reynolds Experience. 2) Measurement of local and average velocity in a closed pipeline. 3) Measurement of friction losses caused by liquid viscosity. 4) Local loss measurement.	9

Wykład		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W1	Fluid statics: 1) Basic concepts. Macroscopic properties of fluids. Idealized fluid models. 2) Types of physical quantity fields. Substantial, material and convective derivative.	2
W2	Fluid statics: 1) Forces acting on the fluid. Euler's theorem. 2) Differential equations of fluid equilibrium. Relative and absolute equilibrium of liquids. Pascal's law. 3) Fluid pressure on plane and curved wall surfaces. Buoyancy. 4) Floating stability of bodies fully and partially submerged in a liquid, metacentre.	5
W3	Elements of fluid kinematics: 1) The path of a fluid element. Stream line. 2) The continuity equation. 3) Volumetric and mass flow rate of fluid.	2
W4	The dynamics of an ideal fluid: 1) Differential equations of motion of an ideal fluid. 2) Bernoulli's integral, Bernoulli equation. 3) Application of the Bernoulli equation in engineering practice.	3

Wykład		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W5	Real Fluid Dynamics: 1) Classic Reynolds experiment. 2) The distribution of tangential stresses and the velocity distribution in the laminar motion of a viscous liquid in a circular pipe. 3) Laminar and turbulent flows. Darcy-Weisbach equation. Nikuradse diagram. Bernoulli equation for real fluid, pressure losses due to internal friction and local obstacles.	3

7 Narzędzia dydaktyczne

N1 Lecture

N2 Table classes

N3 Laboratory

N4 Team work

N5 Consultation

8 Obciążenie pracą studenta

Forma aktywności	Średnia liczba godzin na zrealizowanie aktywności
Godziny kontaktowe z nauczycielem akademickim, w tym:	
Godziny wynikające z planu studiów	60
Konsultacje przedmiotowe	4
Egzaminy i zaliczenia w sesji	2
Godziny bez udziału nauczyciela akademickiego wynikające z nakładu pracy studenta, w tym:	
Przygotowanie się do zajęć, w tym studiowanie zalecanej literatury	40
Opracowanie wyników	15
Przygotowanie raportu, projektu, prezentacji, dyskusji	4
Sumaryczna liczba godzin dla przedmiotu wynikająca z całego nakładu pracy studenta	**125**
Sumaryczna liczba punktów ECTS dla przedmiotu	5.00

9 Sposoby oceny

The final grade for the subject is the weighted average of the grades for each form of classes and the exam.

Ocena formująca

F1 Final test of table classes.

F2 Laboratory exercise report.

F3 Final test from laboratories.

F4 Written exam.

Ocena podsumowująca

P1 Weighted average of forming grades

Warunki zaliczenia przedmiotu

W1 Correct execution of laboratory exercises reports.

W2 The need to obtain a positive evaluation of each learning outcome.

Ocena aktywności bez udziału nauczyciela

B1 Preparation of laboratory exercises reports.

Kryteria oceny

Efekt kształcenia 1	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L1.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L1.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L1.
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L1.
Na ocenę 5.0	The student will define and explain the concepts of the element of fluid, density, compressibility, viscosity, pressure, scalar and vector fields and write the substantial derivative. The student made a flawless report of the laboratory exercise in block L1.
Efekt kształcenia 2	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0.

Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	The student introduces and explains the Euler equilibrium equations, gives the conditions for integrating these equations, derives the dependences on the pressure distribution in the area of the liquid in equilibrium and derives the dependencies on the values of thrust forces and the coordinates of the center of pressure on plain and curved wall surfaces.
Efekt kształcenia 3	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	Student defines the concepts of fluid element path, streamline, flow rate and also derives the continuity equation and its special cases, the ideal fluid equation and the Bernoulli equation.
Efekt kształcenia 4	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0
Na ocenę 5.0	The student derives the equations of motion of an Euler perfect fluid, gives the assumptions for the Bernoulli integral and derives the Bernoulli equation for the perfect fluid and gives its physical and geometric interpretation.
Efekt kształcenia 5	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0.

Na ocenę 5.0	The student defines the concept of Reynolds number, distinguishes between laminar and turbulent motion and derives the dependencies for the velocity distribution, tangential stress distribution in a circular pipe and the Hagen-Poiseuille law, and gives its application in engineering practice.
Efekt kształcenia 6	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	The student integrates the Euler equilibrium equations, pressure distributions in the area of the liquid in equilibrium, determines the thrust forces and the position of the center of pressure on flat and curved walls.
Efekt kształcenia 7	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L2.
Na ocenę 3.5	The student obtained 70% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L2.
Na ocenę 4.0	The student obtained 80% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L2.
Na ocenę 4.5	The student obtained 90% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L2.
Na ocenę 5.0	The student determines the time of full and partial emptying of the tank through small orifice, determines the average velocity and flow rate using a Prandtl tube and a Venturi tube. The student made a flawless report of the laboratory exercise in block L2.
Efekt kształcenia 8	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student obtained 60% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L3.
Na ocenę 3.5	5,0. Student wykonał bezbłędnie sprawozdanie z ćwiczenia laboratoryjnego z bloku L2. / The student obtained 70% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L3.
Na ocenę 4.0	5,0. Student wykonał bezbłędnie sprawozdanie z ćwiczenia laboratoryjnego z bloku L2. / The student obtained 80% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L3.

Na ocenę 4.5	5,0. Student wykonał bezbłędnie sprawozdanie z ćwiczenia laboratoryjnego z bloku L2. / The student obtained 90% of the points required for the grade 5.0. The student made a flawless report of the laboratory exercise in block L3.
Na ocenę 5.0	The student made a flawless report of the laboratory exercise in block L3. The student determines the pressure losses caused by internal friction and local obstacles and uses the Bernoulli equation for the real fluid.
Efekt kształcenia 9	
Na ocenę 2.0	The student does not fulfill the requirements for the grade 3.0
Na ocenę 3.0	The student made at least 60% of the laboratory exercises reports by oneself.
Na ocenę 3.5	The student made at least 70% of the laboratory exercises reports by oneself.
Na ocenę 4.0	The student made at least 80% of the laboratory exercises reports by oneself.
Na ocenę 4.5	The student made at least 90% of the laboratory exercises reports by oneself.
Na ocenę 5.0	The student made all the reports from the laboratory exercises by oneself.

10 Macierz realizacji przedmiotu

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK1		Cel 1	W1	N1 N3 N4 N5	F1 F2 F3 P1
EK2		Cel 2	C1 W2	N1 N2 N5	F1 F3 P1
EK3		Cel 3	W3	N1 N5	F1 F3 P1
EK4		Cel 4	C2 L2 W4	N1 N2 N3 N4 N5	F1 F2 F3 P1
EK5		Cel 6	C3 L3 W5	N1 N2 N3 N4 N5	F1 F2 F3 P1
EK6		Cel 2 Cel 3	C1 W2	N1 N2 N5	F1 F3 P1
EK7		Cel 5	C2 L2 W4	N1 N2 N3 N4 N5	F1 F2 F3 P1
EK8		Cel 6	C3 L3 W5	N1 N2 N3 N4 N5	F1 F2 F3 P1
EK9		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5 Cel 6	L1 L2 L3	N3 N4 N5	F1 F2 F3 P1

11 Wykaz literatury

Literatura podstawowa

[1] Nakayama, Y.; Boucher, R.F. — *Introduction to Fluid Mechanics*, , 2000, Elsevier

[2] B. R. Munson, D. Young, T. Okiishi — *Fundamentals of Fluid Mechanics*, , 2002, J. Wiley& Sons

[3] W. P. Graebel, — *Advanced Fluid Mechanics*, , 2007, Elsevier

12 Informacje o nauczycielach akademickich

Osoba odpowiedzialna za kartę

dr inż., prof. PK Stanisław Walczak (kontakt: `stanislaw.walczak@pk.edu.pl`)

13 Zatwierdzenie karty przedmiotu do realizacji

(miejscowość, data) (odpowiedzialny za przedmiot) (dziekan)