Politechnika Krakowska im. Tadeusza Kościuszki

Karta przedmiotu

obowiązuje studentów rozpoczynających studia w roku akademickim 2023/2024

Wydział Inżynierii Środowiska i Energetyki

Kierunek studiów: Energetyka — Profil: Ogólnoakademicki

Forma sudiów: stacjonarne — Kod kierunku: 11

Stopień studiów: II

Specjalności: Energy systems and machinery

1 Informacje o przedmiocie

Nazwa przedmiotu	Computational Fluid Dynamics
Nazwa przedmiotu w języku angielskim	Computational Fluid Dynamics
Kod przedmiotu	WIŚIE EN oIIS C10 23/24
Kategoria przedmiotu	Przedmioty kierunkowe
Liczba punktów ECTS	3.00
Semestry	2

2 Rodzaj zajęć, liczba godzin w planie studiów

Semestr	Wykład	Cwiczenia	Laboratoria	Laboratoria komputero-we	Projekt	Seminarium
2	0	0	0	30	0	0

3 Cele przedmiotu

Cel 1 The aim of the course is to familiarize students with the basics of CFDs. Students are to understand how numerical flow modeling software works. After completing the course, the student is supposed to understand how to divide geometry into control volumes, how to perform discretization and how to interpret the results of the analyzed object.

Cel 2 The student has to master one of the CFD calculation programs at a basic level.

4 Wymagania wstępne w zakresie wiedzy, umiejętności i innych kompetencji

1 Requirement 1 Knowledge of the basics of fluid mechanics

2 Requirement 2 Knowledge of the basics of thermodynamics

3 Requirement 3 Knowledge of the basics of numerical methods

5 Efekty kształcenia

EK1 Wiedza Educational result 1 Learn the Navier-Stokes equations.

EK2 Umiejętności Educational result 2 The ability to write differential equations of continuity, heat transfer and fluid motion for the control volumes.

EK3 Umiejętności Educational result 3 Technical proficiency in CFD calculation software for the preparation of geometry domain and mesh overlay.

EK4 Umiejętności Educational result 4 Technical proficiency in the computer program for CFD calculation in order to set the boundary conditions, perform calculations and analyze the results.

6 Treści programowe

Laboratoria komputerowe		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
K1	Discussion of repeat materials for students. Basic repetition of the thermodynamics of heat transfer and fluid mechanics.	4
K2	Presentation of the Navier Stokes equation, division of the domain into control volumes, discretion, stability and convergence of calculations.	4
K3	Project 1 - solving the problem of an transient one-dimensional problem. Manual calculations.	4
K4	Project 1 - solving the problem of an transient one-dimensional problem. To develop own computer program to solve the problem defined in Project 1.	5
K5	Project 1 - solving the problem of a transient one-dimensional problem. Creating a model with use of one of the commercial CFD software..	4
K6	Project 2- solving the problem of steady state three-dimensional problem. Creating a model domain from 3D CAD model.	4
K7	Project 2- solving a three-dimensional problem for fluid flow. Performing flow calculations through a 3D area using one of commercial CFD software.	5

7 Narzędzia dydaktyczne

N1 Design exercises classes

N2 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	30
Konsultacje przedmiotowe	12
Egzaminy i zaliczenia w sesji	5
Godziny bez udziału nauczyciela akademickiego wynikające z nakładu pracy studenta, w tym:	
Przygotowanie się do zajęć, w tym studiowanie zalecanej literatury	5
Opracowanie wyników	20
Przygotowanie raportu, projektu, prezentacji, dyskusji	18
Sumaryczna liczba godzin dla przedmiotu wynikająca z całego nakładu pracy studenta	**90**
Sumaryczna liczba punktów ECTS dla przedmiotu	3.00

9 Sposoby oceny

Projekt indywidualny

Ocena formująca

F1 Individual project

Ocena podsumowująca

P1 Project

Warunki zaliczenia przedmiotu

W1 The final grade is the arithmetic mean of all project grades. In order to obtain a positive grade in a course, the student must have at least sufficient credit for all learning outcomes.

Kryteria oceny

Efekt kształcenia 1	
Na ocenę 2.0	Lack of knowledge of the Navier-Stokes equations.
Na ocenę 3.0	The student correctly writes the Navier-Stokes equations and defines the quantities that are in equations.

Na ocenę 3.5	The student can write the general form of the Navier-Stokes equations for the conservation of momentum law. The student correctly writes the Navier-Stokes equations and defines the quantities that are in equations.
Na ocenę 4.0	The student can write the general form of the Navier-Stokes equations for the conservation of momentum law. The student correctly writes the Navier-Stokes equations and defines the quantities that are in equations. For 2D geometry, can write the appropriate equations for one of the selected control volumes. There may be minor errors in writing the equations.
Na ocenę 4.5	The student can write the general form of the Navier-Stokes equations for the conservation of momentum law. The student correctly writes the Navier-Stokes equations and defines the quantities that are in equations. For 2D geometry, can write the appropriate equations for one of the selected control volumes.
Na ocenę 5.0	Student is able to list analytical solutions to equations describing the most common technical cases of Newtonian fluid motion.
Efekt kształcenia 2	
Na ocenę 2.0	Lack of knowledge of differential equations of heat transfer and/or fluid motion
Na ocenę 3.0	The student correctly writes the differential equations of heat transfer and/or fluid motion for the indicated control volume.
Na ocenę 3.5	The student correctly writes the differential equations of heat transfer and/or fluid motion for the indicated control volume. Student correctly divides a 1D domain into control volumes.
Na ocenę 4.0	The student correctly writes the differential equations of heat transfer and/or fluid motion for the indicated control volume. Student correctly divides a 1D domain into control volumes and, writes the heat transfer equations for the indicated boundary conditions. There may be minor errors in writing the equations.
Na ocenę 4.5	The student correctly writes the differential equations of heat transfer and/or fluid motion for the indicated control volume. Student correctly divides a 1D domain into control volumes and, writes the heat transfer equations for the indicated boundary conditions.
Na ocenę 5.0	The student correctly writes the differential equations of heat transfer and/or fluid motion for the indicated control volume. Student correctly divides a 1D domain into control volumes and, writes the heat transfer equations for various boundary conditions. Student is able to simplify notation due to symmetry of the problem.
Efekt kształcenia 3	
Na ocenę 2.0	The 3D model is not suitable for CFD modeling. Computational mesh is incorrect. Calculations cannot be performed due to geometry or mesh errors or incorrectly specified boundary conditions.
Na ocenę 3.0	The student is able to build a 3D geometry and adapt it to a flow model. A computational mesh has been built correctly. The student is able to dense the mesh in places indicated by the tutor.

Na ocenę 3.5	The student is able to build a 3D geometry and adapt it to a flow model. A computational mesh has been built correctly. The student is able to dense the mesh in places where are high gradients of analyzed quantities.
Na ocenę 4.0	The student can build a 3D geometry and adapt it to a flow model, and can modify the geometry of the computational domain and change its dimensions to obtain comparative results. The student correctly builds a computational mesh with appropriate number of elements and dense the computational mesh where large gradients of analyzed quantities are expected. The student builds the grid correctlyl to reproduce the boundary layer at appropriate locations. Distinguishes between symmetric, axisymmetric, and periodic domains. Translated with www.DeepL.com/Translator (free version)
Na ocenę 4.5	The student can build a 3D geometry and adapt it to a flow model, and can modify the geometry of the computational domain and change its dimensions to obtain comparative results. The student correctly builds a computational mesh with appropriate number of elements and dense the computational mesh where large gradients of analyzed quantities are expected. The student builds the grid very well to reproduce the boundary layer at appropriate locations. Distinguishes between symmetric, axisymmetric, and periodic domains. Student is able to create a computational mesh for such domain.
Na ocenę 5.0	The student can build a 3D geometry and adapt it to a flow model, and can modify the geometry of the computational domain and change its dimensions to obtain comparative results. The student correctly builds a computational mesh with appropriate number of elements and dense the computational mesh where large gradients of analyzed quantities are expected. The student builds the mesh excellent to reproduce the boundary layer at appropriate locations. Distinguishes between symmetric, axisymmetric, and periodic domains. Student is able to create a computational mesh for such domain both tetragonal and hexagonal one.
Efekt kształcenia 4	
Na ocenę 2.0	The 3D model is not suitable for CFD modeling. The boundary conditions it's not correct
Na ocenę 3.0	Students correctly set boundary conditions in the programme. Performs calculations so that low residue criteria are met. The student Performs calculations of the effect of grid quality on results. Results are sufficiently interpreted. Results presented in the form of maps graphs. Student presents conclusions from calculations consistent with the obtained results
Na ocenę 3.5	Students correctly set boundary conditions in the programme. Carried out calculations so that the criteria for low residues are met and Monitors at least one physical quantity. The student has carried out calculations of the effect of the quality of the calculation grid on the results. The results were well interpreted. Results are presented in the form of graphical maps, tables, graphs. The student presented the conclusions of the calculations consistent with the obtained results. Minor errors in interpretation of results are allowed in their presentation

Na ocenę 4.0	Students correctly set boundary conditions in the programme. Carries out calculations so that the low residue criteria are met and Monitors at least one physical quantity. Performs calculations Influences the quality of the calculation grid on the results. Is able to correctly interpret the results, and carry out the processing of the results. Presents the results with a legend/range presented. Results presented in the form of graphical maps, tables, graphs. Presented conclusions of the calculations in accordance with the results obtained.
Na ocenę 4.5	The student will correctly set boundary conditions in the programme and will be able to set boundary conditions in the form of a function. Performs calculations so that the criteria for low residues are met and monitors at least one physical quantity. The invariance of the monitored quantity is demonstrated. Calculations of the effect of grid quality on the results have been carried out. The student is able to interpret the results well, and carry out the processing of the results so as to present them in a clear form. Results are presented with an appropriately selected legend/range of the presented quantity. Results are presented in the form of graphical maps, tables, charts. The student presents conclusions from the calculations in line with the results obtained.
Na ocenę 5.0	The student will correctly set boundary conditions in the programme and will be able to set boundary conditions in the form of a function. Performs calculations so that the criteria for low residues are met and monitors at least one physical quantity. The invariance of the monitored quantity is demonstrated. Calculations of the effect of grid quality on the results have been carried out. The student is able to interpret the results very well, and carry out the processing of the results so as to present them in a clear form. Results are presented with an appropriately selected legend/range of the presented quantity. Results are presented in the form of graphical maps, tables, charts. The student presents conclusions from the calculations in line with the results obtained.

10 Macierz realizacji przedmiotu

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK1	K2_W01 K2_W03	Cel 1	K1 K2	N1	F1 P1
EK2	K2_W02 K2_W03 K2_U15	Cel 1	K3 K4	N1 N2	F1 P1
EK3	K2_W03 K2_W07 K2_W14 K2_U15	Cel 2	K5 K6	N1 N2	F1 P1

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK4	K2_U15	Cel 2	K6 K7	N1 N2	F1 P1

11 Wykaz literatury

Literatura podstawowa

[1] **Date A.W.** — *Introduction to Computational Fluid Dynamics*, New Yorl, 2005, CUP

Literatura uzupełniająca

[1] **Anderson J.D.** — *Computational fluids dynamics the basics with applications*, New York, 1995, McDraw-Hill

[2] **AutorKotake Susumu, Kunio Hijikata** — *Numerical Simulations of heat Transfer and fluid flow on a personal Computer*, Tokyo, 1993, Elsevier

12 Informacje o nauczycielach akademickich

Osoba odpowiedzialna za kartę

dr hab. inż. Atrur Cebula (kontakt: `acebula@pk.edu.pl`)

Osoby prowadzące przedmiot

1 dr hab. inż. Artur Cebula (kontakt: `acebula@pk.edu.pl`)

13 Zatwierdzenie karty przedmiotu do realizacji

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

Przyjmuję do realizacji (data i podpisy osób prowadzących przedmiot)

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