Al-Farabi Kazakh National University
Syllabus
NUMERICAL MODELING OF FLUID DYNAMICS PROBLEMS

Fall semester 2016 - 2017 academic year

Code of Discipline	name Discipline	Type	Number of hours per week			Number of credits	ECTS
			Lec	Prac	Lab		
	Numerical modeling of fluid dynamics problems	OK	2	0	2	3	5

Prerequisites	"Fluid Mechanics", "Continuum Mechanics", "Differential Equations", "Mathematical Physics", "Thermodynamics", "CFD".		
Lecturer	**Yerzhan Belyayev, Doctor PhD**	**Office hours**	By timetable of the classes
e-mail	**Yerzhan.Belyaev@kaznu.kz**		
Telephones	8 (727) 377-31-93	**Lecture hall**	By timetable of the classes
Course description			
The aim of the course	To teach students the basic and modern computational technics in Fluid Dynamics, to teach them to understand the basic equations and to solve these equations using numerical procedures. The purpose of discipline is familiarize students with the basic numerical approaches, which are covered with practical examples. Concept of the course is based on the book "Computational Fluid Mechanics and Heat Transfer" by Richard H. Pletcher, John C. Tannehill, Dale A. Anderson. As a result of studying the course, students should know the basic system of equations for compressible flows, numerical methods of solution these equations, pros and cons of that numerical methods.		
learning Outcomes	Necessary knowledge in the basics of Fluid Dynamics and skills to numerically solve the problems of compressible and incompressible flows. General competence: - instrumental – the ability to assess the methodological approaches to carry out their critical analysis; - interpersonal – ability to independently develop and deepen their knowledge and acquire new skills in a professional manner; knowledge of a foreign language in an amount sufficient to communicate freely in arbitrary topics; - system – the ability to plan the steps of solving professional problems and implement them in time; demonstrate independence and original approach to problem solving, the ability to justify and make decisions.		

<table>
<tr><td>List of literature</td><td colspan="3">Main:

1. Richard H. Pletcher, John C. Tannehill, Dale A. Anderson Computational Fluid Mechanics and Heat Transfer //CRC Press, Taylor & Francis Group Third Edition International Standard Book Number-13: 978-1-4665-7830-2 (eBook - PDF).
2. Klaus A. Hoffmann, Steve T. Chiang Computational Fluid Dynamics // Vol. I Fourth Edition. ISBN 0-9623731-0-9, 2000.
3. Culbert B. Laney Computational Gasdynamics // Cambridge University Press 2007, P. 613.
4. T. J. Chung Computational Fluid Dynamics // Cambridge University Press 2002, P. 1012.
5. К. Флетчер Вычислительные методы в динамике жидкостей // Москва «Мир» 1991, Том 1,2. 502 с.

Additional:

1. C. Hirsch Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics // First published by John Wiley & Sons, Ltd, Second Edition 2007, P. 680.
2. Д. Андерсон, Дж. Таннехил, Р. Плетчер Вычислительная гидромеханика и теплообмен // Москва «Мир» 1990, Том 1, 2. 726 с.</td></tr>
<tr><td>Organization</td><td colspan="3"></td></tr>
<tr><td>course Requirements</td><td colspan="3">All the assignments must be completed until due date. Students, who could not earn 50% out of 100% during first or second midterm and final, will be able to work off during an additional term. Late assignment is not accepted except for extenuating circumstances (e.g. field trip, hospitalization). Stu-dent, who failed to meet all kinds of work, is not allowed for passing an exam. In addition, the assess-ment takes into account the activity and attendance of students during class.

Be tolerant and respect other people's opinions. The objections should be formulated in a correct manner. Plagiarism and other forms of cheating are not allowed. Cheating is not accepted during inde-pendent work of student (IWS), midterm and final exam, copying solved problems from others, passing the exam to another student are not allowed also. Student convicted of falsifying any information about the course, any unauthorized upload to the “Intranet” using cheat sheets, will be graded with a final grade «F». For advice on the implementation of IWS, submitting and defending, as well as additional information on the studied material and all the other issues that arose upon studying the course, contact the instructor during his office hours.</td></tr>
<tr><td rowspan="3">evaluation Policy</td><td>Description self study results</td><td>Weigh t</td><td>Description self</td></tr>
<tr><td>Hometasks
Development of a database project
Programming Project
examinations
TOTAL</td><td>35%
10%
15%
<u>40%</u>
100%</td><td>1,2,34,5,6
2,3,4
4,5,6
1,2,3,4,5,6</td></tr>
<tr><td colspan="3">Your final score will be calculated by the formula below:
$$\text{Total score of the course} = \frac{PK1 + PK2}{2} \cdot 0,6 + 0,1ME + 0,3FE$$
Below are minimum estimates in percent:
95% - 100%: A   90% - 94%: A-
85% - 89%: B+   80% - 84%: B   75% - 79%: B-
70% - 74%: C+   65% - 69%: C   60% - 64%: C-
55% - 59%: D+   50% - 54%: D-   0% -49%: F</td></tr>
<tr><td></td><td colspan="3">Appropriate timing of homework or projects may be extended in the event of extenuating circumstances (such as illness, emergencies, emergency, contingency, etc.) in</td></tr>
</table>

discipline Policy	accordance with the University's academic policies. Student participation in discussions and exercises in the classroom will be taken into account in its overall assessment of the discipline. Design issues, dialogue and feedback on the subject matter of discipline are welcomed and encouraged in the classroom, and the teacher in the derivation of the final grade will take into account the participation of each student in the class.

Schedule discipline

Week	Title of the theme	Hour	Grade
1	**Lecture 1.** Partial Differential Equations. **Lab.1.** Physical and Mathematical Classification. **IWM 1.** Wave equation in different forms.	2 1	14
2	**Lecture 2.** Basics of Discretization Methods. **Lab.2.** Difference Representation of Partial Differential Equations. **IWM 2.** Use of Taylor Series.	2 1	14
3	**Lecture 3.** Application of Numerical Methods to Selected Model Equations. **Lab.3.** Heat Equation. **IWM 3.** 1D, 2D, 3D Heat Equation numerical solution.	2 1	14
4	**Lecture 4.** Conservation and other basic principles. **Lab.4.** The CFL condition. **IWM 4.** Upwind and adaptive stencils.	2 1	14
5	**Lecture 5.** Laplace’s Equation. **Lab.5.** Gauss–Seidel Iteration. **IWM 5.** SOR by Lines.	2 1	14
6	**Lecture 6.** Burgers’ Equation (Inviscid). **Lab.6.** Lax–Wendroff Method. **IWM 6.** TVD Schemes.	2 1	14
7	**Lecture 7.** Burgers’ Equation (Viscous). **Lab.7.** FTCS Method. **IWM 7.** Test problem.	2 1	16
	1st control test	1	**100**
	Midterm exam	1	**100**
8	**Lecture 8.** Numerical Methods for the Navier–Stokes Equations. **Lab.8.** Compressible Navier–Stokes Equations. **IWM 8.** Explicit MacCormack Method.	2 1	12
9	**Lecture 9.** Numerical Methods for the Navier–Stokes Equations. **Lab.9.** Incompressible Navier–Stokes Equations. **IWM 9.** Vorticity–Stream Function Approach.	2 1	12
10	**Lecture 10.** Numerical Methods for the Navier–Stokes Equations. **Lab.10.** Incompressible Navier–Stokes Equations. **IWM 10.** Primitive-Variable Approach.	2 1	12
11	**Lecture 11.** Numerical Methods for Inviscid Flow Equations. **Lab.11.** Classical Shock-Capturing Methods. **IWM 11.** Presentation.	2 1	12
12	**Lecture 12.** Numerical Methods for Boundary-Layer-Type Equations. **Lab.12.** Crank–Nicolson and Fully Implicit Methods. **IWM 12.** Presentation.	2 1	12

13	**Lecture 13.** Numerical Methods for the “Parabolized” Navier–Stokes Equations. **Lab.13.** “Parabolized” Navier–Stokes Equations. **IWM 13.** Numerical Solution of PNS Equations.	2 1	12
14	**Lecture 14.** Open FOAM. **Lab.14.** Examples on Open FOAM. **IWM 14.** Prepare a presentation.	2 1	12
15	**Lecture 15.** Comsol Multiphysics. **Lab.15.** Examples on Comsol Multiphysics. **IWM 15.** Prepare a presentation.	2 1	16
	2nd control test	1	100
	Exam		**100**

Dean of the Faculty M.A. Bektemesov

Chairman of the Bureau of the method F.R. Gusmanova

Head of the department Z. Rakisheva

Lecturer Ye. Belyayev