Al-FARABI KAZAKH NATIONAL UNIVERSITY
FACULTY MECHANICS AND MATHEMATICS
Educational program on specialty «050603-Mechanics»

Approved
at the meeting of Academic Council
of the faculty of Mechanics and Mathematics

Protocol №___from « ____»_____ 2015
Dean of the Faculty _____ Bektemesov M.A.

METHODS OF STUDYING TURBULENT FLOW

SYLLABUS

2-nd year master students «050603-Mechanics»,
Fall semester, 3 credits

Lecturer/Labs Teacher: Yerzhan Belyayev, Doctor PhD
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The goals and objectives of the course:

Purpose: To teach students the basic concepts of turbulent flows. To explain and teach the principles of modeling, fundamental axioms and hypotheses, basic system of equations of turbulent flow. The main purpose of this subject is to present to students turbulent flow problems with application examples. The structure of this course is based on the book: "Turbulence Modeling for CFD", author is David C. Wilcox. In this course, students should know the main characteristics and patterns of turbulent flows. Recognizes the problems of turbulent flows, and model them using the mathematical modeling technique.

Objects: The main objective of teaching this subject is to train students to build mathematical model, to understand the fundamentals of turbulent flow, to recognize the RANS, LES, DNS and PDF approaches, to distinguish turbulent boundary layer, mixing layer, turbulence hypotheses and models.

Competence (results of education):

They have to know: basics of turbulent flow, to recognize the RANS, LES, DNS and PDF approaches, to distinguish turbulent boundary layer, mixing layer, turbulence hypotheses and models; the ability to recognize the differential equations describing the physical process of turbulent flow; depending on the classification of differential equations to be able to use and adapt numerical methods for solving and computer programs.

Prerequisites: mathematical analysis, differential equations, mathematical physics equations, continuum mechanics, the theory of the boundary layer, jet theory, probability theory, statistical physics, linear stability theory, numerical methods and computer program (OpenFOAM, Fortran, C ++).

Post-requisites: the theory of turbulent boundary layer flow modeling, jet theory, computational fluid dynamics, chemical reacting flows.

STRUCTURE AND CONTENT OF THE SUBJECT

Week	Title of the theme	Hour	Grade
1	**Lecture 1.** Introduction. Definition of an ideal turbulence model. **Lab.1.** How complex must a turbulence model be? **IWM 1.** Comments on the physics of turbulence. Importance of turbulence in practical situations.	2 1	14
2	**Lecture 2.** General properties of turbulence. **Lab.2.** Turbulence scale and cascade. **IWM 2.** Large eddies and turbulent mixing.	2 1	14
3	**Lecture 3.** The smallest scales of turbulence. **Lab.3.** Example problem. **IWM 3.** Example problem.	2 1	14
4	**Lecture 4.** Spectral representation and the Kolmogorov -5/3 law. **Lab.4.** Example problem. **IWM 4.** Example problem.	2 1	14
5	**Lecture 5.** The law of the wall. **Lab.5.** Power laws. **IWM 5.** Test problems.	2 1	14
6	**Lecture 6.** A brief history of turbulence modeling. **Lab.6.** Test problems. **IWM 6.** Test problems.	2 1	14
7	**Lecture 7.** The closure problem. **Lab.7.** Reynolds averaging. **IWM 7.** Test problems.	2 1	16
	1st control test	1	**100**
	Midterm exam	1	**100**
8	**Lecture 8.** Phase averaging. **Lab.8.** Test problems. **IWM 8.** Test problems.	2 1	12
9	**Lecture 9.** Reynolds-averaged equations. **Lab.9.** Test problems. **IWM 9.** Test problems.	2 1	12
10	**Lecture 10.** The Reynolds-stress equations. **Lab.10.** Test problems. **IWM 10.** Test problems.	2 1	12
11	**Lecture 11.** The scales of turbulence. **Lab.11.** Turbulent intensity. **IWM 11.** Test problems.	2 1	12
12	**Lecture 12.** Two-point correlation tensors and related scales. **Lab.12.** Test problems. **IWM 12.** Test problems.	2 1	12
13	**Lecture 13.** Boussinesq eddy-viscosity approximation. **Lab.13.** Test problems. **IWM 13.** Test problems.	2	12

		1	
14	**Lecture 14.** Molecular transport of momentum. **Lab.14.** Test problems. **IWM 14.** Test problems.	2 1	12
15	**Lecture 15.** The mixing length hypothesis. **Lab.15.** DNS, LES, PDF approaches. **IWM 15.** Prepare a presentation.	2 1	16
	2nd control test	1	100
	Exam		**100**
	TOTAL		**(1CT+2CT)/2*0.6 +0.1*MT+0.3*EX AM**

LIST OF LITERATURE

Main:

1. David C. Wilcox Turbulence Modeling for CFD // 2nd Edition, ISBN 0-9636051-5-1, 2000, P. 540.
2. У. Фрост, Т. Моулден Турбулентность: принципы и применения // Москва «МИР» 1980, С. 535.
3. Хинце И.О. Турбулентность. Ее механизм и теория. М.: Физматгиз, 1963. 680с.

Stephen B. Pope Turbulent Flows // Cambridge University Press, P. 749.

Additional:

1. Методы расчета турбулентных течений /Под ред. В.Колльмана. М.: Мир., 1984. 464с.
2. Брэдшоу П. Введение в турбулентность и ее измерение. М.: Мир, 1974. 278с.
3. Гарбарук А.В., Лапин Ю.В., Стрелец М.Х. Простая алгебраическая модель турбулентности для расчета турбулентного пограничного слоя с положительным перепадом давления // ТВТ. 1999. №1. С.82-86.
4. Рейнольдс А.Дж. Турбулентные течения в инженерных приложениях. М.:Энергия. 1979. 408с.
5. Белов И.А., Исаев С.А., Моделирование турбулентных течений. Учебное пособие Санкт-Петербург 2001, 106с.
6. П. Либби, Ф. Вильямс Турбулентные течения реагирующих газов // Москва «Мир» 1983, С. 325.

GUIDLINES

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). Student, who failed to meet all kinds of work, is not allowed for passing an exam. In addition, the assessment 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 independent 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.

Letter grade	Numerical equivalency	% (percentage)	Grading in a traditional way
A	4,0	95-100	Excellent
A-	3,67	90-94	
B+	3,33	85-89	Good
B	3,0	80-84	
B-	2,67	75-79	
C+	2,33	70-74	Satisfactory
C	2,0	65-69	
C-	1,67	60-64	
D+	1,33	55-59	
D-	1,0	50-54	
F	0	0-49	Unsatisfactory
I (Incomplete)	-	-	«The course is incomplete» (this isn't taken into account when calculating the *GPA)*
P (Pass)	-	-	«Passed» (this isn't taken into account when calculating the *GPA)*
NP (No Pass)	-	-	«Not passed» (this isn't taken into account when calculating the *GPA)*
W (Withdrawal)	-	-	«the course is withdrawn» (this isn't taken into account when calculating the *GPA)*
AW (Academic Withdrawal)			Withdrawn because of academic issues (this isn't taken into account when calculating the *GPA)*
AU (Audit)	-	-	«Audit» (this isn't taken into account when calculating the *GPA)*
Att.		30-60 50-100	Attested
Not att.		0-29 0-49	Not attested
R (Retake)	-	-	Retaking the course

Considered in department meeting
Protocol № __ from «__» _____

Head of the department of Mechanics _____ Z. Rakisheva

Lecturer _____ Ye. Belyayev