**SYLLABUS**

**Fall semester 2021-2022 academic year**

**on the educational program “Mathematical and Computer Modeling”**

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| **Discipline code** | **Discipline title** | **Independent work of students (IWS)** | **Number of hours per week** | | | | | **Number of credits** | **Independent work of students with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** | |
| MMT 7202 | Mathematical simulation of turbulence (RANS) | 5 | 1 | 0 | | 2 | | 3 | 5 |
| **Academic course information** | | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Number of IWS** | | **Form of final control** |
| Online | Theoretical | Semi-formal,  lecture-discussion | | | written | | No less than 3 | | Written exam |
| Lecturer | Abdibekov Ualikhan Seidildaevich,  professor | | | | | |  | | |
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| **Academic presentation of the course** |

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| **Aim of the course** | **Expected Learning Outcomes (LO)**  As a result of studying the discipline the undergraduate will be able to: | **Indicators of LO achievement (ID)**  (for each LO at least 2 indicators) |
| to form the ability of doctoral students to independently solve the problem of researching the problem of turbulence of processes by mathematical methods in the following sequence. | **LO 1.**Description of turbulent processes by mathematical equations; | **AI 1.1** To know basic concepts, ideas and methods  **AI 1.2** To understand the principles of turbulent processes by mathematical equations; |
| **LO 2.** Construction of a mathematical model of the process; | **AI 2.1** Construction of a mathematical model of the process;  **AI 2.2** To be able to build Construction of a mathematical model of the process; |
| **LO 3.**  Selection of closure methods; Constructing semiempirical closure methods | **AI 3.1** To be able to Selection of closure methods;  **AI 3.2** To be able Constructing semiempirical closure methods |
| **LO 4.**  Construction of a mathematical model of turbulent flow for large Reynolds numbers | **AI 4.1** To be able to Construction of a mathematical model of turbulent flow for large Reynolds numbers  **AI 4.2** To be able to Construction of a mathematical model and program code |
| **Prerequisites** | Mathematical and computer modeling of physical procces, continuum mechanics, mechanic of fluid, computational fluid dynamic | |
| **Post requisites** | Mathematical and computer modeling of physical procces, continuum mechanics, mechanic of fluid, computational fluid dynamic | |
| **Information resources** | **Basic:**   1. 1. Монин А.С., Яглом А.М. Статистическая гидромеханика. - М.:Наука,1965. - Ч. 1, - 676 с. 2. Монин А.С., Яглом А.М. Статистическая гидромеханика. - М.:Наука,1965. - Ч. 2 - 686 с. 3. Хинце И.О. Турбулентность. М.:Физматгиз, 1963. - 680 с. 4. Турбулентность. Принципы и применения. - М.: Мир, 1980. - 535 с. 5. Методы расчета турбулентных течений. - М.: Мир, 1984. -464 с. 6. Davidson P.A. Turbulense. An Introduction for Scientists and Engineers, OXFORD University Press 2004. – 678 p. 7. P.Sagaut,S.Deck,M.Terracol\_Multiscale\_and\_Multiresolution\_Approaches\_in\_Turbulence\_Imperial College Press 2006. – 356 p.   **Internet-resources:** Additional educational material, lecture and practical classes, CDS assignments are uploaded to the teaching materials section of the univer.kaznu.kz website. | |

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| **Academic policy of the course in the context of university moral and ethical values** | **Academic behavior rules:**  Compulsory attendance of classes, inadmissibility of lateness, compliance with deadlines for completion and delivery of tasks (CDS, seminars, intermediate exam)  Academic values:  1. Seminars, IWC should be independent, creative  2. Plagiarism, forgery, the use of cheat sheets, cheating at all stages of knowledge control are unacceptable.  3. Students with disabilities can receive counseling at the e-mail address uali1 @ mail.ru |
| **Evaluation and attestation policy** | **Criteria-based evaluation: assessment of learning outcomes in accordance with descriptors (verification of the formation of competencies in midterm control and exams).**  **Summative evaluation: assessment of the presence and activity of work in the audience, assessment of the completed task.**  **The final assessment of discipline = 0.2 ∙ (RK1 + RK (MT) + RK2) +0.4 ∙ IR**  **RK1, RK2 - midterm control, MT - midterm exam, IR - final control.**  **Percentage-rating letter system for assessing students' academic achievements:**  **95% - 100%: А 90% - 94%: А- 85% - 89%: В+**  **80% - 84%: В 75% - 79%: В- 70% - 74%: С+**  **65% - 69%: С 60% - 64%: С- 55% - 59%: D+**  **50% - 54%: D- 25% -49%: FX 0% -24%: F** |

**CALENDAR (SCHEDULE) OF THE IMPLEMENTATION OF THE COURSE CONTENT**

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| Weeks | Topic name | LO | AI | Amount of hours | Maximum score | Form of knowledge assessment | Form of the lesson/ platform |

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| **Module 1. RANS** | | | | | | | |
| 1 | Lecture 1. The nature of turbulent flows | LO 1 | AI 1.1  AI 1.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №1. Related exercises | LO 2 | AI 1.1  AI 1.2 | 2 | 10 | DCT | Webinar/ **Microsoft Teams**  /  **Zoom** |
| 2 | Lecture 2. Averaging procedure for Navier-Stokes equation | LO 2 | AI 2.1  AI 2.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №2. Related exercises | LO 2 | AI 2.1  AI 2.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams** /  **Zoom** |
| 3 | Lecture 3. Local similarity principle in turbulent transport theory | LO 2 | AI 2.1  AI 2.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №3. Related exercises | LO 2 | AI 2.1  AI 2.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams** |
| **IWST 1.** Consultation on the IWS 1 implementation |  |  | 1 |  |  | Webinar /  **Zoom** |
| **IWS 1.** Import objects from AutoCAD into 3DsMax | LO 1 | AI 1.1  AI 1.2 |  | 15 | IT | Webinar /  **Zoom** |
| 4 | Lecture 4. Equations for Reynolds Stress Velocity | LO 2 | AI 2.1  AI 2.2 | 1 |  |  | Webinar /  **Zoom** |
|  | **Lab.** Performance of laboratory work №4. Related exercises | LO 2 | AI 2.1  AI 2.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams** /  **Zoom** |
| 5 | Lecture 5. Semi-empirical relations and hypotheses  closures for the equation of second moments | LO 1 | AI 1.1  AI 1.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №5. Related exercises | LO 1 | AI 1.1  AI 1.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| **IWST 2.** Consultation on the IWS 2 implementation. |  |  | 1 |  |  | Webinar /  **Zoom** |
| Independent work of student with teacher: IWST. | LO 1 | AI 1.2 |  | 15 | IT | Webinar /  **Zoom** |
|  | **CONTROL 1** | | | | 100 |  |  |
| **Module 2. Turbulent viscosity models** | | | | | | | |
| 6 | Lecture 6. Pulsation structure of turbulent  flows in a homogeneous medium | LO 2 | AI 2.1  AI 2.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №6. Related exercises | LO 2 | AI 2.1  AI 2.2 | 2 | 10 | DCT | Webinar/ **Microsoft Teams / Zoom** |
| 7 | Lecture 7. Influence of Archimedean forces on the structure of turbulence | LO 2 | AI 2.1 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №7. Related exercises | LO 2 | AI 2.1  AI 2.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams** /  **Zoom** |
| 8 | Lecture 8. Pulsation structure of turbulent flows in a stratified environment | LO 3 | AI 3.1 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №8. Related exercises | LO 1 | AI 1.1  AI 1.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
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| **IWS 3.** Independent work of student with teacher: IWST. | LO 3 | AI 3.1 |  | 10 | IT | Webinar /  **Zoom** |
| 9 | Lecture 9. Influence of temperature and concentration on  the structure of turbulent flow | LO 3 | AI 3.1  AI 3.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №9. Related exercises | LO 3 | AI 3.1  AI 3.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| 10 | Lecture 10. Pulsation structure of turbulent transverse flows of the conducting liquid magnetic field | LO 3 | AI 3.1  AI 3.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №10. Related exercises | LO 3 | AI 3.1  AI 3.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| **IWST 4.** Independent work of student with teacher: IWST. |  |  | 1 | 20 |  | Webinar /  **Zoom** |
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|  | **МТ (Midterm Exam)** | | | | 100 |  |  |
| **Module 3. Reynolds stress and related models** | | | | | | | |
| 11 | Lecture 11. Pulsation structure of turbulent flows in a curved domain | LO 4 | AI 4.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №11. Related exercises | LO 4 | AI 4.1  AI 5.2 | 2 | 10 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| 12 | Lecture 12. Pulsation structure of turbulent admixture transfer in curved domain | LO 4 | AI 4.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №12. Related exercises | LO 4 | AI 4.1  AI 5.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| **Module 3. The influence of rotation, stratification, and magnetic fields on turbulence** | | | | | | | |
| 13 | Lecture 13. The influence of rotation, stratification, and magnetic fields on turbulence | LO 4 | AI 4.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №13. Related exercises | LO 4 | AI 4.1  AI 5.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| 14 | Lecture 14. The influence of magnetic fields the MHD equations | LO 4 | AI 4.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №14. Related exercises | LO 4 | AI 4.1  AI 5.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| 15 | Lecture 15. Turbulence total energy balance | LO 4 | AI 4.2 | 1 |  |  | Webinar /  **Zoom** |
| **Lab.** Performance of laboratory work №15. Related exercises | LO 4 | AI 4.1  AI 5.2 | 2 | 15 | DCT | Webinar/ **Microsoft Teams**/  **Zoom** |
| **IWST 5.** Consultation on the IWS 5 implementation |  |  | 1 |  |  | Webinar /  **Zoom** |
| Independent work of student with teacher: IWST | LO 4 | AI 4.2 |  | 30 | IT | Webinar /  **Zoom** |
|  | **CONTROL 3** | | | | 100 |  |  |
| **Exam** | | | | | 100 |  |  |

[Abbreviations: QS – questions for self-examination; DCT – drawing and constructing tasks; IT – individual tasks; CW – control work; MT – midterm].

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