**SYLLABUS**

**Fall semester 2020-2021 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)** | |
| ChMNTTT  7302 | Numerical simulation of unsteady three dimensional turbulence flows | 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. Sagaut P. Large Eddy Simulation for Incompressible Flows. Springer, Berlin Heidelberg, 1998, 558 p.  2. Волков К.Н, Емельянов В.Н. Моделирование крупных вихрей в расчетах турбулентных течений.-М.: ФИЗМАТЛИТ, 2008. – 368 с.  3. Xi Jiang, Choi-Hong Lai. Numerical Techniques for Direct and Large-Eddy Simulations. CRC Press, NY, 2009, - 264 p.  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. General Algorithms for Incompressible Navier-Stokes Equations** | | | | | | | |
| 1 | Lecture 1. An introduction to modeling and simulation. | 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. Matrix sweep method. | 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. High-Order Fractional-Step Methods | 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. Time Discretizations. Adams-Bashforth Methods. Adams-Moulton Methods. | 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. Furies Method for Three Dimensional Poisson Equations. | 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. Large eddy simulation for turbulent flow** | | | | | | | |
| 6 | Lecture 6. Three Classical filters for LES. | 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. Decomposition of the non-linear term. Leonard’s decomposition. | 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. Improvement of models in the physical space. Dynamic procedures for computing the constants. Germano-Lilly dynamic procedure. | 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. Deterministic statistical models. Localized dinamic model with energy equation. | 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. Anisotropic models. Model based on splitting technique. | 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. Structural modeling for LES** | | | | | | | |
| 11 | Lecture 11. Non-linear models. Dynamic non-linear model. | 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. Scale similarity models. Dynamic similarity model. | 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.** 3D modeling | | | | | | | |
| 13 | Lecture 13. Differential subgrid stress models. Deardorff model. Subgrid viscosity models. | 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. Mixed modeling. One parameter mixed dynamic model. | 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. Incompressible Navier-Stokes equations with turbulence models. | 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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