**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)** |
| ChMNTTT7302 | 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, creative2. 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 1.1AI 1.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №1. Related exercises | LO 2 | AI 1.1AI 1.2 | 2 | 10 | DCT  | Webinar/ **Microsoft Teams**  /**Zoom** |
| 2 | Lecture 2. Matrix sweep method. | LO 2 | AI 2.1AI 2.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №2. Related exercises | LO 2 | AI 2.1AI 2.2 | 2 | 15 | DCT  | Webinar/ **Microsoft Teams** /**Zoom** |
| 3 | Lecture 3. High-Order Fractional-Step Methods  | LO 2 | AI 2.1AI 2.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №3. Related exercises | LO 2 | AI 2.1AI 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 1.1AI 1.2 |  | 15 | IT | Webinar /**Zoom** |
| 4 | Lecture 4. Time Discretizations. Adams-Bashforth Methods. Adams-Moulton Methods. | LO 2 | AI 2.1AI 2.2 | 1 |  |  | Webinar /**Zoom** |
|  | **Lab.** Performance of laboratory work №4. Related exercises | LO 2 | AI 2.1AI 2.2 | 2 | 15 | DCT  | Webinar/ **Microsoft Teams** /**Zoom** |
| 5 | Lecture 5. Furies Method for Three Dimensional Poisson Equations. | LO 1 | AI 1.1AI 1.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №5. Related exercises | LO 1 | AI 1.1AI 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 2.1AI 2.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №6. Related exercises | LO 2 | AI 2.1AI 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 2.1AI 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 1.1AI 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 3.1AI 3.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №9. Related exercises | LO 3 | AI 3.1AI 3.2 | 2 | 15 | DCT  | Webinar/ **Microsoft Teams**/**Zoom** |
| 10 | Lecture 10. Anisotropic models. Model based on splitting technique. | LO 3 | AI 3.1AI 3.2 | 1 |  |  | Webinar /**Zoom** |
| **Lab.** Performance of laboratory work №10. Related exercises | LO 3 | AI 3.1AI 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 4.1AI 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 4.1AI 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 4.1AI 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 4.1AI 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 4.1AI 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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