**SYLLABUS**

**Fall semester 2024-2025 academic year**

**Educational program "8D05403 - Mechanics"**

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| **ID**  **and name**  **of course** | **Independent work**  **of the student**  **(IWS)** | | **Number of credits** | | | **General**  **number**  **of credits** | **Independent work**  **of the student**  **under the guidance**  **of a teacher (IWST)** |
| **Lectures (L)** | **Seminars or**  **Practical classes (PC)** | **Lab. classes (LC)** |
| IIZM 7302, AI in Mechanics Problems | The number of IWD is 5. | | 1.7 |  | 3.3 | 5.0 | The number of  IWDT is 4. |
| **ACADEMIC INFORMATION ABOUT THE COURSE** | | | | | | | |
| **Learning Format** | **Cycle,**  **component** | **Lecture**  **types** | | **Types**  **of practical classes** | | **Form and platform final control** | |
| *Offline* |  | Offline classes | | Lab classes using Python on laptops. | | Project with presentation and report. | |
| **Lecturer - (s)** | Yerzhan Belyayev | | | | |
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| **Assistant - (s)** |  | | | | |
| **e-mail :** |  | | | | |
| **Phone :** |  | | | | |
| **ACADEMIC COURSE PRESENTATION**  This course is designed to enhance students' academic writing skills, focusing on developing their ability to communicate effectively in scholarly contexts. Through a series of lectures, discussions, and practical exercises, students will learn the principles of academic writing, covering various essential topics. | | | | | | | |
| **Purpose**  **of the course** | **Expected Learning Outcomes (LO) \*** | | | | | **Indicators of LO achievement (ID)** | |
| To teach doctoral students the fundamentals of numerical optimization methods, mathematical statistics, machine learning, and artificial intelligence. | 1. Roots of equations and polynomials. | | | | | * 1. Roots of equations – bisection method, Newton Raphson method. Etc. | |
| 1.2 Roots of polynomials – Muller’s method and Bairstow’s method. | |
| 2. Optimization – one-dimensional and multidimensional constrained and unconstrained optimization. | | | | | 2.1 One-dimensional unconstrained optimization – Golden section method, Newton’s method, Brent’s method. | |
| 2.2 Multidimensional unconstrained optimization – Direct methods and Gradient methods. | |
| 3. Curve fitting. | | | | | 3.1 Least-squares regression. | |
| 3.2 Interpolation. | |
| 4. ML – classification and regression. | | | | | 4.1 Supervised learning. | |
| 4.2 Unsupervised learning and preprocessing. | |
| 5. Approaching ML problem. | | | | | 5.1 Algorithm chains and pipelines. | |
| 5.2 Working with text data. | |
| **Prerequisites** | I. Mathematics  II. Fortran, C ++, Python programming languages (will be an advantage);  III. Physics  IV. Differential Equations;  V. Matlab, Mathcad, Excel, Maple (will be an advantage). | | | | | | |
| **Post requisites** | I. Mathematical and Computer Modeling in Mechanical Engineering;  II. Basics of Mechanics;  III. Numerical Methods and Algorithms;  IV. Python programming language.  V. ML and AI basic algorithms. | | | | | | |
| **Learning Resources** | **literature**:  **Basic:**   1. Steven C. Chapra, Raymond P. Canale Numerical Methods for Engineers // 6th Edition, McGrawHill Higher Education, ISBN 978-0-07-340106-5, P. 994., 2010. 2. Jaan Kiusalaas Numerical Methods in Engineering with Python 3.0 // Cambridge University Press. - 2013. – P. 423. 3. Andreas C. Muller and Sarah Guido Introduction to machine learning with Python // 1st Edition, O’Reilly, ISBN 978-1-449-36941-5. P. 376, 2016.   **Additional:**   1. «Укус Питона» – «A Byte of Python» по-русски, Swaroop C H (Translated by Vladimir Smolyar), 2013, 159 стр. 2. Марк Лутц , Изучаем Python, 4-е издание, 2011 г., 1280 стр. 3. С. Шапошникова , Основы программирования на Python, 2011 г., 44 стр. 4. <https://www.python.org/downloads/> 5. <http://www.jetbrains.com/pycharm/> | | | | | | |

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| **Academic**  **course policy** | | The academic policy of the course is determined by [the Academic Policy](https://univer.kaznu.kz/Content/instructions/%D0%90%D0%BA%D0%B0%D0%B4%D0%B5%D0%BC%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B0%D1%8F%20%D0%BF%D0%BE%D0%BB%D0%B8%D1%82%D0%B8%D0%BA%D0%B0.pdf) and [the Policy of Academic Integrity of Al-Farabi Kazakh National University .](https://univer.kaznu.kz/Content/instructions/%D0%9F%D0%BE%D0%BB%D0%B8%D1%82%D0%B8%D0%BA%D0%B0%20%D0%B0%D0%BA%D0%B0%D0%B4%D0%B5%D0%BC%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%BE%D0%B9%20%D1%87%D0%B5%D1%81%D1%82%D0%BD%D0%BE%D1%81%D1%82%D0%B8.pdf)  Documents are available on the main page of IS Univer .  **Integration of science and education.** The research work of students, undergraduates and doctoral students is a deepening of the educational process. It is organized directly at the departments, laboratories, scientific and design departments of the university, in student scientific and technical associations. Independent work of students at all levels of education is aimed at developing research skills and competencies based on obtaining new knowledge using modern research and information technologies. A research university teacher integrates the results of scientific activities into the topics of lectures and seminars (practical) classes, laboratory classes and into the tasks of the IWST, IWS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions andassignments.  **Attendance.** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course. Failure to meet deadlines results in loss of points.  **Аcademic honesty.** Practical/laboratory classes, IWS develop the student's independence, critical thinking, and creativity. Plagiarism, forgery, the use of cheat sheets, cheating at all stages of completing tasks are unacceptable.  Compliance with academic honesty during the period of theoretical training and at exams, in addition to the main policies, is regulated by [the "Rules for the final control"](https://univer.kaznu.kz/Content/instructions/%D0%9F%D1%80%D0%B0%D0%B2%D0%B8%D0%BB%D0%B0%20%D0%BF%D1%80%D0%BE%D0%B2%D0%B5%D0%B4%D0%B5%D0%BD%D0%B8%D1%8F%20%D0%B8%D1%82%D0%BE%D0%B3%D0%BE%D0%B2%D0%BE%D0%B3%D0%BE%20%D0%BA%D0%BE%D0%BD%D1%82%D1%80%D0%BE%D0%BB%D1%8F%20%D0%9B%D0%AD%D0%A1%202022-2023%20%D1%83%D1%87%D0%B3%D0%BE%D0%B4%20%D1%80%D1%83%D1%81%D1%8F%D0%B7%D1%8B%D0%BA%D0%B5.pdf) , ["Instructions for the final control of the autumn / spring semester of the current academic year"](https://univer.kaznu.kz/Content/instructions/%D0%98%D0%BD%D1%81%D1%82%D1%80%D1%83%D0%BA%D1%86%D0%B8%D1%8F%20%D0%B4%D0%BB%D1%8F%20%D0%B8%D1%82%D0%BE%D0%B3%D0%BE%D0%B2%D0%BE%D0%B3%D0%BE%20%D0%BA%D0%BE%D0%BD%D1%82%D1%80%D0%BE%D0%BB%D1%8F%20%D0%B2%D0%B5%D1%81%D0%B5%D0%BD%D0%BD%D0%B5%D0%B3%D0%BE%20%D1%81%D0%B5%D0%BC%D0%B5%D1%81%D1%82%D1%80%D0%B0%202022-2023.pdf) , "Regulations on checking students' text documents for borrowings".  Documents are available on the main page of IS Univer .  **Basic principles of inclusive education.** The educational environment of the university is conceived as a safe place where there is always support and equal attitude from the teacher to all students and students to each other, regardless of gender, race / ethnicity, religious beliefs, socio-economic status, physical health of the student, etc. All people need the support and friendship of peers and fellow students. For all students, progress is more about what they can do than what they can't. Diversity enhances all aspects of life.  All students, especially those with disabilities, can receive counseling assistance by phone +7 771 491 33 44 / e- mail: [yerzhan.belyaev@kaznu.edu.kz](mailto:yerzhan.belyaev@kaznu.edu.kz)  **Integration MOOC (massive open online course).** In the case of integrating MOOC into the course, all students need to register for MOOC. The deadlines for passing MOOC modules must be strictly observed in accordance with the course study schedule.  **ATTENTION!** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course, as well as in the MOOC. Failure to meet deadlines results in loss of points. | | | | |
| **INFORMATION ABOUT TEACHING, LEARNING AND ASSESSMENT** | | | | | | |
| **Score-rating letter system of assessment of accounting for educational achievements** | | | | | **Assessment Methods** | |
| **Grade** | **Digital**  **equivalent**  **points** | | **points,**  **% content** | **Assessment according to the traditional system** | **Criteria-based assessment** is the process of correlating actual learning outcomes with expected learning outcomes based on clearly defined criteria. Based on formative and summative assessment.  **Formative assessment is** a type of assessment that is carried out in the course of daily learning activities. It is the current measure of progress. Provides an operational relationship between the student and the teacher. It allows you to determine the capabilities of the student, identify difficulties, help achieve the best results, timely correct the educational process for the teacher. The performance of tasks, the activity of work in the classroom during lectures, seminars, practical exercises (discussions, quizzes, debates, round tables, laboratory work, etc.) are evaluated. Acquired knowledge and competencies are assessed.  **Summative assessment** -type of assessment, which is carried out upon completion of the study of the section in accordance with the program of the course.Conducted 3-4 times per semester when performing IWD. This is the assessment of mastering the expected learning outcomes in relation to the descriptors. Allows you to determine and fix the level of mastering the course for a certain period. Learning outcomes are evaluated. | |
| A | 4.0 \_ | | 95-100 | Great |
| A- | 3.67 | | 90-94 |
| B+ | 3.33 | | 85-89 | Fine |
| B | 3.0 | | 80-84 | **Formative and summative assessment** | **Points % content** |
| B- | 2.67 | | 75-79 | Activity at lectures | 5 |
| C+ | 2.33 | | 70-74 | Work in practical classes | 20 |
| C | 2.0 | | 65-69 | Satisfactorily | Independent work | 25 |
| C- | 1.67 | | 60-64 | Design and creative activity | 10 |
| D+ | 1.33 | | 55-59 | Unsatisfactory | Final control (exam) | 40 |
| D | 1.0 | | 50-54 | TOTAL | 100 |
| **Calendar (schedule) for the implementation of the content of the course. Methods of teaching and learning.** | | | | | | |

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| **A week** | **Topic name** | **Number of hours** | **Max.**  **ball** |
| **MODULE 1** | | | |
| **1** | L 1. Mathematical modeling concept. Roots of equations. Bisection method. False-position method. | 1 | 1.5 |
| Lab 1. Coding bisection method in Python. Solving several example problems. | 2 | 4 |
| Homework 1. Greenhouse gases and rainwater – Civil/Environmental engineering problem. |  | 2 |
| **2** | L 2. Roots of equations. Newton-Raphson method. Secant method. Brent’s method. | 1 | 1.5 |
| Lab 2. Coding Newton-Raphson and Secant methods in Python. | 2 | 4 |
| Homework 2. Ideal and nonideal gas laws – Chemical/Bio engineering. |  | 2 |
| IWDT P 1. Consultations on the implementation of IWD 1. |  |  |
| **3** | L 3. Roots of polynomials. Mullers’s method. Bairstow’s method. | 1 | 1.5 |
| Lab 3. Coding Mullers’s method and Bairstow’s method using Python. | 2 | 4 |
| Homework 3. Design of an electrical circuit – Electrical engineering. |  | 2 |
| IWDT 1. Finding roots of equations or polynomials implementation in the PhD research area. Pipe friction – Mechanical/Aerospace engineering. |  | 7.5 |
| **4** | L 4. Optimization. Mathematical background. One-dimensional unconstrained optimization. Golden section search. Parabolic interpolation. Newton’s method. Brent’s method. | 1 | 1.5 |
| Lab 4. Coding in Python Golden section search. Parabolic interpolation. Newton’s method. Brent’s method. | 2 | 4 |
| Homework 4. Least-cost design of a tank – Chemical/Bio engineering. |  | 2 |
| **5** | L 5. Multidimensional unconstrained optimization. Direct Methods. Gradient Methods. | 1 | 1.5 |
| Lab 5. Coding in Python Direct Methods. Gradient Methods. | 2 | 4 |
| Homework 5. Least-cost treatment of wastewater – Civil/Environmental engineering. |  | 2 |
| **MODULE 2 Title** | | | |
| **6** | L 6. Constrained optimization. Linear programming. Nonlinear constrained optimization. | 1 | 1.5 |
| Lab 6. Optimization with software packages. | 2 | 4 |
| Homework 6. Maximum power transfer for circuit – Electrical engineering. |  | 2 |
| IWDT 2. Consultations on the implementation of IWD 2 |  |  |
| **7** | L 7. Curve fitting. Mathematical background. Least-squares regression. Linear regression. Polynomial regression. Multiple linear regression. Nonlinear regression. | 1 | 1.5 |
| Lab 7. Coding in Python Linear regression. Polynomial regression. Multiple linear regression. Nonlinear regression. | 2 | 4 |
| Homework 7. Linear regression and population models – Chemical/Bio engineering. |  | 2 |
| IWDT 7. Equilibrium and minimum potential energy – Mechanical/Aerospace engineering. |  | 7.5 |
| **Midterm control 1** | | | **100** |
| **8** | L 8. Interpolation. Newton’s interpolating polynomials. Lagrange interpolating polynomials. Spline interpolation. Multidimensional interpolation. | 1 | 1.5 |
| Lab 8. Coding in Python Newton’s interpolating polynomials. Lagrange interpolating polynomials. Spline interpolation. Multidimensional interpolation. | 2 | 4 |
| Homework 8. Use of splines to estimate heat transfer – Civil/Environmental Engineering. |  | 2 |
| IWDT 3. Consultations on the implementation of IWD 2 |  |  |
| **9** | L 9. Fourier approximation. DFT. FFT. | 1 | 1.5 |
| Lab 9. Coding in Python DFT and FFT. | 2 | 4 |
| Homework 9. Fourier analysis – Electrical Engineering. |  | 2 |
| IWDT 2. Analysis of experimental data – Mechanical/Aerospace Engineering. |  | 7.5 |
| **10** | L 10. Supervised learning. Classification and regression. | 1 | 1.5 |
| Lab 10. Coding in Python with examples for supervised ML algorithms. | 2 | 4 |
| Homework 10. Neural networks and deep learning concept. |  | 2 |
| IWDT 4. Consultation on the implementation of IWD 3. |  |  |
| **MODULE 3** | | | |
| **11** | L 11. Unsupervised learning and preprocessing. | 1 | 1.5 |
| Lab 11. Preprocessing and scaling. Dimensionality reduction, feature extraction, and manifold learning. Clustering. | 2 | 4 |
| Homework 11. Comparing and evaluating clustering algorithms. |  | 2 |
| IWDT 3. Summary and outlook for unsupervised learning and preprocessing. |  | 7.5 |
| **12** | L 12. Representing data and engineering features. | 1 | 1.5 |
| Lab 12. Coding with Python for binning, discretization, linear models, and trees. | 2 | 4 |
| Homework 12. Summary and outlook for representing data and engineering features. |  | 2 |
| **13** | L 13. Model evaluation and improvement. | 1 | 1.5 |
| Lab 13. Cross-validation. Grid search. Evaluating metrics and scoring. | 2 | 4 |
| Homework 13. Summary and outlook for model evaluation and improvement. |  | 2 |
| IWDT 5. Consultation on the implementation of IWD 4. |  |  |
| **14** | L 14. Algorithm chains and pipelines. | 1 | 1.5 |
| Lab 14. Parameter selection with preprocessing. The general pipeline interface. | 2 | 4 |
| Homework 14. Grid-searching preprocessing steps and model parameters. |  | 2 |
| **15** | L 15. Working with text data. | 1 | 1.5 |
| Lab 15. Example application: sentiment analysis of movie reviews. | 2 | 4 |
| Homework 15. Summary and outlook working with text data. |  | 2 |
| IWD 4. Approaching a machine learning problem. |  | 7.5 |
| **Midterm control 2** | | | **100** |
| **Final control (exam)** | | | **100** |
| **TOTAL for course** | | | **100** |

**Dean \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N. Doszhan**

**Head of Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ D. Turalina**

**Lecturer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Ye. Belyayev**

**RUBRICATOR OF THE SUMMATIVE ASSESSMENT**

**CRITERIA EVALUATION OF LEARNING OUTCOMES**

**Group presentation "Teaching profession in Kazakhstan" (30% of 100% RK)**

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| --- | --- | --- | --- | --- |
| **Criterion** | **"Excellent"**  25-30% | **"Good"**  20-20% | **"Satisfactory"**  15-20% | **"Unsatisfactory"**  0 – 15% |
| **Understanding theories and concepts of the professional identity of the teacher and the teaching profession** | Deep understanding of theories, concepts of the professional identity of the teacher and the teaching profession. | Understanding theories, concepts of the professional identity of the teacher and the teaching profession. | Limited understanding of theories, concepts of the professional identity of the teacher and the teaching profession. | Superficial understanding / lack of understanding of theories, concepts of the professional identity of the teacher and the teaching profession. |
| **Awareness of key issues of the professional identity of the teacher and the teaching profession in Kazakhstan** | Competent correlation of the key concepts of the professional identity of the teacher and the teaching profession with the context of Kazakhstan. Excellent substantiation of arguments with evidence from empirical research (for example, based on interviews or statistical analysis). | There is a connection between the concepts of professional identity of a teacher and the teaching profession with the context of Kazakhstan. The arguments are backed by evidence from empirical research. | Limited correlation of the professional identity of the teacher and the concepts of the teaching profession with the context of Kazakhstan. Limited use of evidence from empirical research | Insignificant connection / lack of connection between the concepts of the teacher's professional identity and the context of Kazakhstan. Little or no empirical research is used. |
| **Pilot Study** | Excellent use of the results of pilot studies (interviews or surveys) in the presentation | Good use of the results of pilot studies (interviews or surveys) in the presentation. | Satisfactory use of the results of pilot studies (interviews or surveys) in the presentation. | Poor use of the results of pilot studies (interviews or surveys) in the presentation. |
| **Suggestion of policy or practical recommendations/suggestions** | Offers very good policy and/or practical advice or suggestions for improving the professional identity and teaching profession in Kazakhstan. | Offers some policy and/or practical recommendations or suggestions for improving the professional identity and teaching profession in Kazakhstan. | Limited policy and practical recommendations. Recommendations are non-essential, not based on rigorous analysis, and are shallow. | Little or no policy and practice advice, or advice of very low quality. |
| **Presentation,**  **teamwork** | Excellent, attractive presentation, excellent quality of visuals, slides, materials, excellent teamwork. | Good engagement, good quality visuals, slides or other materials, good teamwork. | Satisfactory level of involvement, satisfactory quality of materials, satisfactory level of teamwork. | Low engagement, low quality content, poor teamwork. |