**SYLLABUS**

**Fall semester 2023-2024 academic year**

**Educational program “6B06102 - Information Systems”**

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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)** | **Practical classes (PT)** | | **Lab. Classes (LC)** |
| 76215 Parallel programming | 4 | | 1,7 | 0 | | 3,3 | 5 | 7 |
| **Academic Course Information** | | | | | | | | |
| **Learning**  **Format** | **Cycle,**  **Component** | **Lecture types** | | | **Types of practical classes** | | **Form and platform final control** | |
| Offline | MD, University component | Problem-oriented | | | Learning the concepts of object-oriented programming and implementing programs to practice practical skills | | Test, Moodle | |
| **Lecturer - (s)** | Karyukin Vladislav Igorevich | | | | | |
| **e-mail:** | [vladislav.karyukin@gmail.com](mailto:vladislav.karyukin@gmail.com)  [vladislav.karyukin@kaznu.kz](mailto:vladislav.karyukin@kaznu.kz) | | | | | |
| **Phone:** | +77019405992 | | | | | |
| **Assistant – (s)** | – | | | | | |
| **e-mail:** | – | | | | | |
| **Phone:** | – | | | | | |
| **ACADEMIC COURSE PRESENTATION** | | | | | | | | |

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| **Purpose**  **of the course** | **Expected Learning Outcomes (LO) \*** | **Indicators of LO achievement (ID)** |
| This course is aimed at studying the concepts of object-oriented programming, as well as understanding their practical implementation by solving real-life practical problems of varying complexity.  Within the discipline, the following aspects will be considered: principles of construction of parallel computing systems, modeling and analysis of parallel computations, principles of developing parallel algorithms and programs | 1. (cognitive) Know the theoretical and methodological concepts of parallel programming | 1.1 ability to create basic and advanced programs using parallelisms |
| 1.2 Know the peculiarities of working with cores and memory |
| 1.3 Knowledge of Concurrency Application Development Methods |
| 1. (functional) Apply knowledge of mpi4py, Celery, PyCUDA, and NumbaPRO libraries | 2.1 Develop programs for parallel computing |
| 2.2 Using Libraries for Parallel Computing |
| 2.3developing multifunctional applications that both developers and users understand |
| 1. **(**functional) Developing programs of various complexity levels: from a simple console to a product of academic and industrial importance. | 3.1 Be able to implement program code using parallelism |
| 3.2 Be able to configure applications |
| 3.3 Be able to create applications on Python |
| 1. (system) Building complex, multifunctional applications | 4.1 Creating Parallel Computing Modules |
| 4.2 constructing interaction of various structural elements between each other |
| 4.3 Modifying and Editing Applications |
| 5. (system) Creating Parallel Computing Applications on the GPU | 5.1 Create a New Application |
| 5.2 Implement Parallel Computing on Video Cards |
| 5.3 Test Applications |
| **Prerequisites** | Programming on Python language, Programming in Java | |
| **Post requisites** |  | |
| **Learning**  **Resources** | **Literature:**  **Main:** Python parallel programming cookbook by Giancarlo Zaccone. Packt publishing, 2015.Python for Everybody: Exploring Data in Python 3 by Dr. Charles Russell Severance, Sue Blumenberg, Elliott Hauser, Aimee Andrion, 2016Python Cookbook: Recipes for Mastering Python 3 3rd Edition, Kindle Edition by David Beazley, Brian K. Jones, 2013Advanced Python Development: Using Powerful Language Features in Real-World Applications 1st ed. Edition by Matthew Wilkes, 2021.Learning Python 5ed: Powerful Object-Oriented Programming, Mark Lutz, 2013.Fluent Python: Clear, Concise, and Effective Programming, Luciano Ramalho, 2015. **Additional:**   1. Natural Language Processing with Python and spaCy: A Practical Introduction, Yuli Vasiliev, 2021 2. Learning Scientific Programming with Python, Christian Hill, 2021   **Internet resources:**   * Parallel programming. <https://aaltoscicomp.github.io/python-for-scicomp/parallel/>  Parallel Processing in Python. <https://www.geeksforgeeks.org/parallel-processing-in-python/>  * A guide to Python multiprocessing and parallel programming. https://www.sitepoint.com/python-multiprocessing-parallel-programming/   **Software and Internet Resources:**  Python IDE, Anaconda Navigator Python, Microsoft Visual Studio, PyCharm, Microsoft Office Word, WinRAR, WordPad, Power Point, Adobe Reader, Paint. | |

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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 [vladislav.karyukin@gmail.com](mailto:vladislav.karyukin@gmail.com) / +77019405992 or via video link in MS Teams |
| **INFORMATION ABOUT TEACHING, LEARNING AND ASSESSMENT** | |

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| **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 IWS. 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 | 0 |
| C+ | 2.33 | 70-74 | Work in practical classes | 25 |
| С | 2.0 | 65-69 | Satisfactorily | Independent work | 25 |
| С- | 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.**  **score \* \* \*** |
| **MODULE 1 Foundations of parallel computing** | | | |
| 1 | **L 1.** Getting started with parallel computing | 1 | 0 |
| **LC 1.** Python in a parallel world | 2 | 5 |
| 2 | **L 2.** Memory organization | 1 | 0 |
| **LC 2.** Thread-based Parallelism | 2 | 5 |
| **IWST 1.** Consultation on the implementation of IWS 1 |  |  |
| 3 | **L 3.** Parallel programming models | 1 | 0 |
| **LC 3.** Thread synchronization with Lock and RLock | 2 | 10 |
| **IWS 1.** Implementation of project with parallel operations in Python |  | 20 |
| 4 | **L 4.** Python in parallel programming | 1 | 0 |
| **LC 4.** Thread synchronization with a condition | 2 | 10 |
| **IWST 2.** Acceptance of IWS 1 |  |  |
| 5 | **L 5.** Thread-based parallelism | 1 | 0 |
| **LC 5.** Process-based parallelism | 2 | 10 |
| **IWST 3.** Consultation on the implementation of IWS 2 |  |  |
| **Module 2 Multiprocessing with Python** | | | |
| 6 | **L 6.** Thread synchronization with Lock and RLock | 1 | 0 |
| **LC 6.** Using a process in a subclass | 2 | 10 |
| **IWS 2.** Creating the application with distributed processes |  | 20 |
| 7 | **L 7.** Multiprocessing | 1 | 0 |
| **Lab 7.** Using the mpi4py Python module | 2 | 10 |
| **IWST 4.** Acceptance of IWS 2 |  |  |
| **Midterm control 1** | | | 100 |
| 8 | **L 8.** Subclass processes | 1 | 0 |
| **LC 8.** Distributed python | 2 | 5 |
| **IWST 5.** Consultation on the implementation of IWS 3 |  |  |
| 9 | **L 9.** mpi4py Python module | 1 | 0 |
| **LC 9.** Scientific computing with SCOOP | 2 | 5 |
| **IWS 3.** Test |  | 5 |
| 10 | **L 10.** Distributed python | 1 | 0 |
| **LC 10.** GPU programming with Python | 2 | 20 |
| **IWST 6.** Acceptance of IWS 3 |  |  |
| **Module 3 Parallel programming on GPU** | | | |
| 11 | **L 11.** GPU programming with python | 1 | 0 |
| **LC 11.** Matrix multiplication with PyCUDA | 2 | 5 |
| **IWST 7.** Consultation on the implementation of IWS 4 |  |  |
| 12 | **L 12.** PyCUDA | 1 | 0 |
| **LC 12.** GPU programming with Numba | 2 | 10 |
| **IWS 4.** Developing the parallel application with CUDA |  | 20 |
| 13 | **L 13.** PyCUDA matrix multiplication | 1 | 0 |
| **LC 13.** Using the PyOpenCL module | 2 | 10 |
| 14 | **L 14.** NumbaPRO | 1 | 0 |
| **LC 14.** Evaluating element-wise operations with PyOpenCL | 2 | 10 |
| **15** | **L 15.** PyOpenCL application | 1 | 0 |
| **Lab 15.** Creating the parallel computing application | 2 | 10 |
| **Midterm control 1** | | | **100** |
| **Final control (exam)** | | | **100** |
| **TOTAL for course** | | | **100** |

**Dean \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Urmashev B.A.**

**Head of the Department of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Mussiraliyeva Sh. Zh.**

**Lecturer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Karyukin V.I.**

**RUBRICATOR OF THE SUMMATIVE ASSESSMENT**

**CRITERIA EVALUATION OF LEARNING OUTCOMES**

**IWS 1.** Implementation of project with parallel operations in Python (20% of 100% of MC1)

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| --- | --- | --- | --- | --- |
| **Criterion** | **"Excellent"**  **Max. weight in 16-20%** | **"Good"**  **Max. weight in 11-15%** | **"Satisfactory"**  **Max. weight in 5-10%** | **"Unsatisfactory"**  **Max. weight in 1-4%** |
| Knowledge and understanding of basic concepts of parallel operations | Understanding the degree of relevance and reliability of the data found. Knowledge and understanding of all parallel operations | Understanding the degree of relevance and reliability of the data found. Knowledge of most operations with parallel operations | Limited understanding of the relevance and validity of parallel operations | Superficial understanding/lack of understanding of the degree of relevance and reliability of the data found. Lack of concept of parallel operations |
| Coding skills | Clear presentation of the program code, absence of syntax errors in the code | There are small logical errors in the program code | A large number of logical and syntax errors in the program code, which make it practically unworkable | No code or just a few lines of code |
| Writing a report | The writing demonstrates clarity, conciseness, and accuracy | The writing demonstrates clarity, conciseness and correctness. Mostly no errors | There are some key errors in the writing and the clarity needs improvement. | The writing is unclear and it is difficult to follow the content. Lots of errors in the text |

**IWS 2.** Creating the application with distributed processes (20% of 100% of MC1)

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| --- | --- | --- | --- | --- |
| **Criterion** | **"Excellent"**  **Max. weight in 16-20%** | **"Good"**  **Max. weight in 11-15%** | **"Satisfactory"**  **Max. weight in 5-10%** | **"Unsatisfactory"**  **Max. weight in 1-4%** |
| Knowledge and understanding of basic concepts of distributed processes | Understanding the degree of relevance and reliability of the data found. Knowledge and understanding of all distributed processes | Understanding the degree of relevance and reliability of the data found. Knowledge of most operations with distributed processes | Limited understanding of the relevance and validity of distributed processes | Superficial understanding/lack of understanding of the degree of relevance and reliability of the data found. Lack of concept of distributed processes |
| Coding skills | Clear presentation of the program code, absence of syntax errors in the code | There are small logical errors in the program code | A large number of logical and syntax errors in the program code, which make it practically unworkable | No code or just a few lines of code |
| Writing a report | The writing demonstrates clarity, conciseness, and accuracy | The writing demonstrates clarity, conciseness and correctness. Mostly no errors | There are some key errors in the writing and the clarity needs improvement. | The writing is unclear and it is difficult to follow the content. Lots of errors in the text |

**IWS 3.** Writing a test **(20% of 100% MC2)**

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| --- | --- | --- | --- | --- |
| **Criterion** | **"Excellent"**  **Max. weight in 16-20%** | **"Good"**  **Max. weight in 11-15%** | **"Satisfactory"**  **Max. weight in 5-10%** | **"Unsatisfactory"**  **Max. weight in 1-4%** |
| Knowledge of solutions to test tasks | Full understanding of all test tasks and the correct answers to them | Almost complete understanding of test tasks and answers to them | Partial understanding of test tasks | Lack of understanding of test tasks and answers to questions asked |
| Writing program code for test tasks | Clear presentation of the program code, absence of syntax errors in the code | There are small logical errors in the program code | A large number of logical and syntax errors in the program code, which make it practically unworkable | No code or just a few lines of code |
| Writing a report | The writing demonstrates clarity, conciseness, and accuracy | The writing demonstrates clarity, conciseness and correctness. Mostly no errors | There are some key errors in the writing and the clarity needs improvement. | The writing is unclear and it is difficult to follow the content. Lots of errors in the text |

**IWS 4.** Developing the parallel application with CUDA (20% of 100% of MC2)

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| --- | --- | --- | --- | --- |
| **Criterion** | **"Excellent"**  **Max. weight in 16-20%** | **"Good"**  **Max. weight in 11-15%** | **"Satisfactory"**  **Max. weight in 5-10%** | **"Unsatisfactory"**  **Max. weight in 1-4%** |
| Knowledge and understanding of basic concepts of parallel applications with CUDA | Understanding the degree of relevance and reliability of the data found. Knowledge and understanding of parallel applications with CUDA | Understanding the degree of relevance and reliability of the data found. Knowledge of most operations with parallel applications with CUDA | Limited understanding of the relevance and validity of parallel applications with CUDA | Superficial understanding/lack of understanding of the degree of relevance and reliability of the data found. Lack of concept of parallel applications with CUDA |
| Coding skills | Clear presentation of the program code, absence of syntax errors in the code | There are small logical errors in the program code | A large number of logical and syntax errors in the program code, which make it practically unworkable | No code or just a few lines of code |
| Writing a report | The writing demonstrates clarity, conciseness, and accuracy | The writing demonstrates clarity, conciseness and correctness. Mostly no errors | There are some key errors in the writing and the clarity needs improvement. | The writing is unclear and it is difficult to follow the content. Lots of errors in the text |