Faculty of Computer Technology and Cybersecurity

Department of Mathematical and Computer Modeling

Approved

Dean of faculty

IITU JSC

\_\_\_\_\_\_\_\_\_\_\_\_\_Seilova N.A.

«\_\_\_\_» \_\_\_\_\_\_\_\_\_\_ 2024

**SYLLABUS  
(ACADEMIC PROGRAM)**

**Course (code, title):** MAT6504 Computational Mathematics

(code, title):

**Major (code, title)**: B057 – Information Technologies

(code, title):

**Educational program** 6B06112- Data Science, 6B06101 – Computer science

(code, title)

**Year:** 3 **Semester:** 5 **Number of credits**: 6 ECTS

**Lectures:**  15 hours

**Practical classes:** 15 hours

**Laboratory classes:** 30 hours

**T/SIS:** 120 hours

**Total:** 180 hours

**Cycle:** BS

**Final assessment form**: Written Examination, 120 minutes, with proctor

Almaty 2024

Academic program of the course (code, title) MAT6504 Computational Mathematics has been developed on the basis of EP Data Science and Computer Science.

Academic program has been reviewed at the meeting of Mathematical and Computer Modeling department.

Minutes № 12 dated «10» June 2024.

Head of the Department\_\_\_\_\_\_\_\_\_\_\_ Ydyrys A.Zh., PhD, Associate Professor

signature full name, title, degree

Author \_\_\_\_\_\_\_\_\_\_\_ Tokmukhamedova F.K., Msc, Assistant-Professor

signature full name, title, degree

The working academic program was approved at the meeting of the Council for Academic Quality of the Faculty

Minutes № 16 dated "17" June 2024.

Head of the Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ A. Ajibayeva

Signature

for Educational and Methodological Activities

|  |  |
| --- | --- |
| **1. GENERAL INFORMATION** | |
| Faculty | Computer Technologies and Cybersecurity |
| Major code and title | B057 – Information Technologies |
| Educational program code and title | 6B06112 – Data Science, 6B06101 – Computer Science |
| Course, semester | 3rd course, 5th semester |
| Subject category | Profiling |
| Number of credits (ECTS) | 6 |
| Prerequisites | Mathematical Analysis, Algorithms, and programming languages |
| Postrequisites | Numerical Analysis |
| Lecturer | Tokmukhamedova F.K., Msc, Assistant-Professor, f.tokmukhamedova@iitu.edu.kz  807 room |
| **2. GOALS, OBJECTIVES AND LEARNING OUTCOMES OF THE COURSE**  **Course goal:** The students will be introduced with principal numerical methods of algebra and analysis. Moreover, students will launch programs for mathematical problems on laboratory works and practical classes.  **Course objectives:**  1. study analytical and numerical methods for solving the problems of algebra and analysis;  2. write algorithms for problems, which are being solved and launch a program;  3. conduct numerical calculations and analyze the obtained results. | |
| The course goal: the students will be introduced with principal numerical methods of algebra and analysis. Moreover, students will launch programs for mathematical problems on laboratory works and practical classes. | |
| **The objectives of the course are**  1. study analytical and numerical methods for solving the problems of algebra and analysis;  2. write algorithms for problems, which are being solved and launch a program;  3. conduct numerical calculations and analyze the obtained results. | |
| **Learning outcomes of the course**   * Knowledge: describe the basic methods of computational mathematics * Understanding: bring out formulas of numerical methods * Applications: write algorithms and software implementations of numerical methods * Analysis: carry out computational experiments and analyze the results of calculations * Synthesis: revise the terms of the problem being solved and again carry out calculations * Evaluation: recommend the numerical methods for solving applied problems * Apply mathematical models and methods of various processes (ON4) * Create mathematical models using the methods of modern information technologies. (ON8) | |
| **3. COURSE DESCRIPTION**  In this discipline an iterative processes of mathematical analysis, interpolation by splines, the methods for solving the system of linear equation solution and Cauchy Problem for simple differential equations are studied. Algorithms are developed and programs for the problem are launched. The numerical calculations are provided. | |
| **4. COURSE POLICY**  **Students are forbidden to:**   * submit any tasks after the deadline. The mark for late submissions is decreased; * cheat. Plagiarized papers shall not be graded; * be late for classes. Three times' tardy amounts to one absence; * retake any tests, unless there is a valid reason for missing them; * use mobile phones in class; * chew gum in class.   **Students should always**   * be appropriately dressed (formal/semi- formal styles are acceptable); * show consideration for and mutual support of teachers and other students; * let the teacher know of any problems arising in connection with English studies. | |
| **5. LITERATURE** | |
| **Basic literature**   1. Mazumder, S. Numerical mtnhods for partial differential equations. - Amsterdam: Akademik press, 2022.- 461p. 2. Nicholas, J. Daras. Computational Mathematics and Variational Analysis / USA: Springer, 2020.- 577p.   **Supplementary literature**:   1. Фаддеев, М.А. Основные методы вычислительной математики: Учебное пособие / СПб.: Издательство "Лань", 2008.- 160 с.- (Учебники для вузов. Специальная литература). | |

1. **Course schedule**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Week/**  **date** | **Course topics** | **References** | **Lectures**  (1 h/w) | **Practical sessions**  (1 h/w) | **Lab. sessions** (2 h/w) | **TSIS**  (1 h/w) | **SIS**  (7 h/w) |
| 1 | Absolute and relative error. Calculating the value of a polynomial. Horner method. Comparison of different variants of the calculation. | [1] | 1 | 1 | 2 | 1 | 7 |
| 2 | Numerical methods for solving a system of linear algebraic equations.  The direct way of the Gauss method. Calculation formulas. Algorithm. The inverse way of the Gauss method. Derivation of calculation formulas. The hollow algorithm of the Gaussian method. | [1],[2] | 1 | 1 | 2 | 1 | 7 |
| 3 | Gauss method for finding the determinant and the inverse matrix. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 4 | The method of square roots for solving system of linear algebraic equations. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 5 | Simple-iteration method. Derivation of calculation formulas. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 6 | Seidel's method. Derivation of calculation formulas. Iteration. Breakpoint. The algorithm of the Seidel method. Verification of the validity of the system solution. Calculation error. The discrepancy. Verification of the validity of the system solution. | [3] | 1 | 1 | 2 | 1 | 7 |
| 7 | Solution of nonlinear equations. Branch roots. Newton's method. Simple iteration method. The problem of choice of the initial approximation. Algorithm. Example. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 8 | Interpolation. Formulation of the problem. Basic and fractional nodes. Spline of the first order. The accuracy of the first order spline. Average error and standard deviation. Algorithm. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 9 | Spline of the second order. Statement of the problem interpolation. Table. The spline formula is of the second order. Derivation of formulas for spline coefficients. Algorithm for calculating a second-order spline. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 10 | Spline of the third order. Statement of the problem interpolation. Table. The spline formula is of the second order. Derivation of formulas for spline coefficients. Algorithm for calculating a second-order spline. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 11 | Proof of the third-order spline convergence. Convergence order. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 12 | An approximate method for calculating a definite integral. Square curvilinear trapezium. The formula of rectangles. The error of the method. Examples. Algorithm of the method. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 13 | Approximate computation of a definite integral by the trapezoid method. Error. Algorithm. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 14 | Approximate calculation of a definite integral by the Simpson method. Error. Algorithm. | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
| 15 | The solution of the Cauchy problem by Euler's method | [1]-[3] | 1 | 1 | 2 | 1 | 7 |
|  | **Total hours:** | **180** | **15** | **15** | **30** | **15** | **105** |

1. **List of topics/ assignments for practical and laboratory classes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| № | Topic Title | Number of hours | References | Form of reporting | Deadline |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Horner’s method | 3 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 2 | Gauss method | 4 | [1]-[3] | Submission to Teams  (10 points) | Next class |
| 3 | Method of square roots | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 4 | Simple iteration method/ Seidel’s method | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 5 | Newton’s method | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 6 | Interpolation. Spline of the first order | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 7 | Spline of the second order | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 8 | Spline of the third order | 4 | [1]-[3] | Submission to Teams  (10 points) | Next class |
| 9 | Rectangles method | 3 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 10 | Trapezoid method | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 11 | Simpson’s method | 4 | [1]-[3] | Submission to Teams  (8 points) | Next class |
| 12 | Euler’s method | 3 | [1]-[3] | Submission to Teams  (8 points) | Next class |

1. **List of topics/assignments for TSIS/SIS**

Proper organization of students’ independent study is the key to the formation of skills in mastering, learning, assimilation and systematization of acquired knowledge, ensuring a high level of academic performance in the learning process

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| № | Topic/Assignment title | Number of hours | References | Form of reporting | Deadline |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Horner’s method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 2 | Gauss method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 3 | Method of squre roots | 10 | [1]-[3] | Code review (no grading) | Next class |
| 4 | Simple iteration method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 5 | Seidel’s method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 6 | Newton’s method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 7 | Interpolation. Spline of the first order | 10 | [1]-[3] | Code review (no grading) | Next class |
| 8 | Spline of the second order | 10 | [1]-[3] | Code review (no grading) | Next class |
| 9 | Spline of the third order | 10 | [1]-[3] | Code review (no grading) | Next class |
| 10 | Rectangle’s, trapezoid method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 11 | Simpson’s method | 10 | [1]-[3] | Code review (no grading) | Next class |
| 12 | Euler’s method | 10 | [1]-[3] | Code review (no grading) | Next class |

1. **System for evaluating student performance in a discipline:**

Each type of educational work is evaluated on a 100-point scale and is included in the average assessment of the current control, taking into account the weighting coefficient in accordance with the table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Period** | **Assignments** | **Maximum score** | Weighting coefficient | **Total** |
| 1st attestation | Laboratory defence (labs #1, 3, 4, 5, 6 – 8 p., lab #2 – 10 p.) | 100 | 0,5 | **100** |
| Midterm | 100 | 0,5 |
| 2nd attestation | Laboratory defence (labs #7, 9, 10, 11 – 8 p., lab #8 – 10 p.) | 100 | 0,5 | **100** |
| Endterm | 100 | 0,5 |
| **Exam** | | | | **100** |
| Total | **0,3\*1stAtt+0,3\*2ndAtt+0,4\*Ex** | | | **100** |

\*If the number of absences exceeds 20%, student will be automatically scheduled for a Retake (summer semester)

1. **Assessment criteria:**

The point-rating letter system for assessing the educational achievements of students with their interpretation in the traditional grading scale:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Letter Grade | Numerical equivalent | Points (%) | Traditional system assessment | General description of grading criteria |
| А | 4,0 | 95-100 | Excellent | The student has knowledge of the subject in the full scope of the curriculum, understands the discipline deeply enough; shows a high level of knowledge that exceeds the volume provided by the syllabus, gives an exhaustive answer |
| А- | 3,67 | 90-94 | The student has knowledge of the subject in the full scope of the curriculum, understands the discipline deeply enough; gives an exhaustive answer |
| В+ | 3,33 | 85-89 | Good | The student shows a complete, well-founded knowledge of the subject, but the answers did not always highlight the main idea, rational methods of calculation were not always used; the answers were mostly brief and sometimes unclear. |
| В | 3,0 | 80-84 |
| В- | 2,67 | 75-79 |
| С+ | 2,33 | 70-74 |
| C | 2,0 | 65-69 | Satisfactory | The student demonstrates sufficient knowledge of the subject, but without proper depth and justification, the answers are unclear and without proper logical sequence. |
| С- | 1,67 | 60-64 |
| D+ | 1,33 | 55-59 |
| D | 1,0 | 50-54 |
| FX | 0,5 | 25-49 | Unsatisfactory | The student demonstrates insufficient knowledge of the subject, positive answers were not given to individual questions. |
| F | 0 | 0-24 | The student demonstrates a very low level of knowledge of the subject. |

1. **Assessment and evaluation materials (exam questions)**

List of exam questions on lecture topics.

* Horner’s method
* Gauss method 1
* Cramer’s method
* Simple iteration method
* Seidel’s method
* Newton’s method
* Interpolation
* Spline of the first order
* Spline of the second order
* Rectangle’s, trapezoid method
* Simpson’s method
* Euler’s method

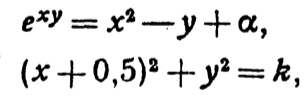
Examination will be provided in the written form. Duration: 120 minutes. Student will have to provide derivation of the method for theoretical questions and evaluation of the function by certain method by hand. The manual calculator is allowed to use during the exam.

Sample card:

**Task 1. [30p]** Explain Gauss method for solving SLAE. A procedure of choosing the main element. Give an example. Provide an algorithm.

**Task 2. [30p]** Describe the spline of the second order. Derivation of the coefficients. Obtain the order of approximation.

**Task 3. [40p]** Solve by the Newton’s method, m = 5, , provide 3 iterations:

 .

1. **An inclusive education**

* This syllabus exemplifies components that foster inclusivity, including:
* A learning-centered course description
* Clear descriptions of course goals and assessment criteria
* An accessible design (i.e. the schedule in table format)

This course:

* Offering flexibility around assignment and attendance policies, including personalized statements regarding support for students with disabilities
* Utilizes language, policies, principles, and the syllabus structure itself to promote equal access and opportunities for all students
* Provides all students with all the necessary educational materials (lectures, laboratory works etc.), uploaded to the Platonus and Teams platform