Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Computer Systems Software Department

SOFTWARE METHODS OF EXPERIMENTAL DATA PROCESSING

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of Higher Education	***First (bachelor's)***
Field of Study	*12 Information Technologies*
Specialty	*121 Software Engineering*
Education Program	*Software Engineering of Multimedia and Information Retrieval Systems*
Type of Course	*Selective*
Mode of Studies	*full-time*
Year of studies, semester	*4th year, autumn semester*
ECTS workload	*Lectures: 36 hours, laboratory classes: 18 hours, independent work: 66 hours.*
Testing and assessment	*Assessment, modular control work, calendar control*
Course Schedule	*According to the schedule for the spring semester of the current academic year (rozklad.kpi.ua)*
Language of Instruction	*English*
Course Instructors	Lecturer: *Ph.D., Associate Professor, Onai Mykola* Practical training: *Ph.D., Associate Professor, Onai Mykola*

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

The study of the discipline "Software Methods of Experimental Data Processing" allows students of higher education to develop the competencies necessary for solving complex problems of professional activity related to the development of software systems for solving typical problems that arise during the analysis of large volumes of accumulated experimental data.

The purpose *of studying the discipline "Software Methods of Experimental Data Processing" is to form in students the ability to carry out innovative activities related to the development of software systems for processing a large volume of accumulated experimental data.*

The subject of *the discipline "Software Methods of Experimental Data Processing" is software methods of analysis and processing of a large volume of accumulated experimental data.*

The study of the discipline "Software Methods of Experimental Data Processing" strengthens the formation of ***professional competences (PC) in students of education****, necessary for solving practical tasks of professional activity:*
PC14 *Aptitude for algorithmic and logical thinking.*
PC18 *Ability to apply the acquired fundamental mathematical knowledge to development of calculation methods and information retrieval systems.*

The study of the discipline "Software Methods of Experimental Data Processing" contributes to the formation in students of the following ***program learning outcomes*** *(PLO) according to the educational program:*
PLO01 *To analyze, purposefully search for and select for the information and reference resources and knowledge necessary for solving professional tasks, taking into account modern achievements of science and technology.*

PLO25 *To know and to be able to use fundamental mathematical tools to build algorithms and develop modern software.*

PLO26 *To be able to develop and use methods and algorithms for the approximate solution of mathematical problems solution in the design of multimedia and information retrieval systems.*

2. Prerequisites and post-requisites of the course (the place of the course in the structural-logical scheme of studies in accordance with educational program)

The successful study of the discipline "Software Methods of Experimental Data Processing" is preceded by the study of the discipline "Algorithmic support of multimedia and information-search systems" of the curriculum for bachelors in the specialty 121 Software Engineering.

The theoretical knowledge and practical skills obtained as a result of mastering the discipline "Software Methods of Experimental Data Processing" can be useful for conducting scientific research and completing bachelor's qualification work.

3. Content of the course

The discipline "Software Methods of Processing Experimental Data" involves the study of topics:

Topic 1. Software approximation of functions

Topic 2. Numerical differentiation and integration

Topic 3. Development of a software system for tabular integration and solving the Cauchy matrix problem

Modular control work

Test

4. Educational materials and resources

Basic literature:

1. Andrunyk V.A. Numerical methods in computer sciences: textbook / Andrunyk V.A., Vysotska V.A., Pasichnyk V.V., Chirun L.B., Chirun L.V. Ch // Volume 2 edited by V.V. Pasichnyka - Lviv: Novy Svit Publishing House, 2020. - 536 p
Use to study the principles of solving mathematical problems that arise during the construction of mathematical models. The materials are freely available on the Internet.

Additional literature:

2. William H. Press Numerical Recipes in C. The Art of Scientific Computing / William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery // Cambridge University Press. - 1018 p.
Use to master practical skills in the discipline.
3. Walter Gautschi Numerical Analysis [Electronic resource], 2012. Access mode: http://www.ikiu.ac.ir/public-files/profiles/items/090ad_1410599906.pdf
Use to master the theoretical material of the discipline.
4. Singular Value Decomposition [Electronic resource] Access mode: https://www.cs.cmu.edu/~venkatg/teaching/CStheory-infoage/book-chapter-4.pdf
Use to study the general structure of the singular matrix decomposition. The materials are freely available on the Internet.

5. Courtney Remani Numerical Methods for Solving Systems of Nonlinear Equations [Electronic resource], 2013.
Access mode: https://www.lakeheadu.ca/sites/default/files/uploads/77/docs/RemaniFinal.pdf

Use to study the principles of solving nonlinear equations. The materials are freely available on the Internet.

6. McDonough JM Computational Numerical Analysis [Electronic resource], 2007. Access mode: http://web.engr.uky.edu/~acfd/egr537-lctrs.pdf

Use to master practical skills in the discipline.

Educational content

5. Methodology of mastering the discipline (educational component)

No.	*Type of training session*	*Description of the training session*
		Topic 1. Software approximation of functions
1	*Lecture 1 . Lagrange interpolation polynomial*	*Definition of the terms approximation, interpolation, extrapolation. Vandermond matrix. Lagrange interpolation polynomial. Linear, quadratic and cubic interpolation. Bicubic interpolation. The residual term of the Lagrange interpolation polynomial. Aitken's interpolation scheme.* *Task on SRS: consider examples of approximation using the Lagrange interpolation polynomial and the Aitken scheme.*
2	*Computer workshop 1*	*Task: Develop software components for finding approximate values of tabular functions.*
3	*Lecture 2. Finite difference interpolation formulas. General concepts*	*The concept of finite difference. Finite difference order. Connection of finite differences with derivatives. Diagonal table of finite differences.* *Task on SRS: to analyze the proposed ways of presenting finite differences.*
4	*Computer workshop 2*	*Task: To develop software components for visualization of the graph of the approximated function.*
5	*Lecture 3. Finite difference interpolation formulas. Newton's interpolation polynomials*	*Newton's first interpolation polynomial. Newton's second interpolation polynomial. Newton's interpolation formulas* *Task on SRS: consider examples of approximation using Newton's interpolation polynomials.*
6	*Lecture 4. Finite difference interpolation formulas. Central interpolation formulas*	*Central interpolation formulas. The first Gaussian interpolation polynomial. The second Gaussian interpolation polynomial. Stirling's interpolation formula. Bessel's interpolation formula.* *Task on SRS: consider examples of approximation using central finite-difference interpolation formulas.*
7	*Lecture 5. Newton's interpolation formula for unequally spaced nodes*	*Concept of split difference. Divided difference order. Split Difference Table. Newton's first interpolation formula for unequally spaced nodes. Newton's second interpolation formula for unequally spaced nodes.* *Task on SRS: derive Newton's second interpolation formula for unequally spaced nodes.*

8	*Computer workshop 3*	*Task: Develop software components for performing interpolation using the interpolation formula for unequally spaced nodes (choose the formula according to the option).*
9	*Lecture 6. Interpolation splines with continuous first derivative on uniform grids of nodes*	*Basics of function interpolation and justification of spline input. Basic definitions of splines and their image forms. Built-in MatLab functions for working with splines*
10	*Lecture 7. Discrete spline bases*	*The method of constructing an interpolation quadratic spline. The method of constructing an interpolation cubic spline. Estimation of the error of the interpolation spline*
11	*Computer workshop 4*	*Task: Develop a program for interpolation using splines.*
12	*Lecture 8. The method of least squares*	*Methods of constructing empirical spline functions by the method of least squares. Analytical method of constructing linear splines. Construction of smoothing Hermitian splines*
13	*Computer workshop 5*	*Task: Develop a program for interpolation using splines.*
14	*Modular control work. Part 1*	
Topic 2. Numerical differentiation and integration		
15	*Lecture 9. Numerical differentiation*	*Finite difference formula of numerical differentiation. Symmetric and asymmetric formula of numerical differentiation. The residual term of numerical differentiation formulas. Order of accuracy of formulas of numerical differentiation.* *Task on SRS: to analyze different methods of numerical differentiation.*
1 6	*Lecture 10. General ideas for constructing numerical integration formulas*	*The Riemann integral. The Riemann integral sum and its role in numerical methods. Examples of cases when it is impossible to use the Newton-Leibnitz formula. The geometric meaning of the definite integral* *The task on the SRS: to analyze the connection between numerical integration formulas and numerical differentiation formulas.*
17	*Lecture 11. Quadrature formulas of rectangles. Family of Newton-Cotes quadrature formulas*	*General formula of rectangles. Quadrature formula of left, right and middle rectangles. Local error of the simplest formula of rectangles. Global error of the quadrature formula of rectangles. Family of Newton-Cotes quadrature formulas. Cotes coefficients. The simplest quadrature formulas derived from the Newton-Cotes formulas.* *Task on SRS: consider examples of numerical integration using the Newton-Cotes formula.*
18	*Computer workshop 6*	*Task: To develop a program for numerical integration by the method given by option*
19	*Lecture 12. Composite quadrature formulas of trapezoids and Simpson. Runge's principle of*	*The simplest and most complex quadrature formula for trapezoids. Simpson's simplest and most complex quadrature formula. The residual term of the combined quadrature formulas of Tarpez and Simpson. Connections between formulas of*

	practical error estimation and Romberg's algorithm	*rectangles, trapezoids and Simpson. Richardson Amendment. Runge's principle of practical error estimation. Generalized Richardson Amendment. Algorithm of rectangles-trapezoids. Romberg's algorithm.* *Task on SRS: consider examples of numerical integration using the trapezoid formula and Simpson's formula.*
20	*Computer workshop 7*	*Task: To develop a program for numerical integration by the method given by option*
Topic 3. Development of a software system for tabular integration and solving the Cauchy matrix problem		
21	*Lecture 13. Euler's method of solving ordinary differential equations*	*The general form of the ordinary differential equation. The order of the ordinary differential equation. General solution of the ordinary differential equation. Formulation of the Cauchy problem. A geometric way of deriving Euler's method. Derivation of Euler's method using Taylor's formula. A differential way of deriving Euler's method. A quadrature way of deriving Euler's method.* *Task on SRS: consider examples of solving ordinary differential equations by Euler's method.*
22	*Lecture 14. Modifications of Euler's method of solving ordinary differential equations*	*Euler's Implicit Method. Trapezium method. Hoyne's method. Euler-Cauchy method. Milne's method. Improved Euler's method.* *Task on SRS: consider examples of solving ordinary differential equations using modifications of Euler's method.*
23	*Computer workshop 8*	*Task: Develop software components for solving the Cauchy problem.*
24	*Lecture 15. Generalization of Euler's method of solving ordinary differential equations*	*Basic principles of construction of Runge-Kutta methods. A one-parameter family of second-order Runge-Kutta methods. The midpoint method as a variant of Runge-Kutta methods.* *Task on SRS: consider examples of solving ordinary differential equations by the Runge-Kutta method of the second order.*
25	*Lecture 16. Modifications of Runge-Kutta methods for solving ordinary differential equations*	*Fourth-order Runge-Kutta method. The Kutta-Merson method. Criterion for stopping the iterative process for Runge-Kutta methods.* *Task on SRS: to consider examples of solving ordinary differential equations by the Runge-Kutta method of the fourth order.*
26	*Computer workshop 9*	*Results*
27	*Modular control work. Part 2*	

6. Independent work of a student/graduate student

The discipline "Software Methods of Experimental Data Processing" is based on independent preparation for classroom classes on theoretical and practical topics.

No. z/p	*The name of the topic submitted for independent processing*	*Number of hours*	*literature*

1	*Preparation for lectures*	*16*	*1-6*
2	*Preparation for a computer workshop*	*27*	*1-6*
3	*Preparation for modular control work. Part 1*	*9*	*1-6*
4	*Preparation for modular control work. Part 2*	*9*	*1-6*
5	*Preparation for the test*	*5*	*1-6*

Policy and Assessment

7. Policy of academic discipline (educational component)

Attending classes. *Absence from a classroom session does not involve the calculation of penalty points, since the student's final rating score is formed solely on the basis of the evaluation of study results. At the same time, discussion of the results of the thematic tasks, as well as presentation / public speaking and participation in discussions and additions at seminars will be evaluated during classroom classes. In order to actively participate in the work of the seminar, the student prepares for a specific seminar class in literature as recommended by the teacher . Participation in the work of the seminar also involves the preparation of reports and co-reports within all classes.*

Missed evaluation control measures. *Every student has the right to make up lessons missed for a valid reason (hospital, mobility, etc.) at the expense of independent work. More details at the link: https://kpi.ua/files/n3277.pdf .*

The procedure for contesting the results of assessment control measures. *A student may raise any issue relating to the assessment procedure and expect it to be dealt with in accordance with pre-defined procedures. Students have the right to challenge the results of control measures with arguments, explaining which criteria they disagree with according to the evaluation. Calendar control is carried out in order to improve the quality of students' education and monitor the student's fulfillment of the syllabus requirements.*

Academic integrity. *The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code .*

Norms of ethical behavior. *Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code .*

Inclusive education. *The acquisition of knowledge and skills in the course of studying the discipline "Research activity in computer engineering" can be accessible to most people with special educational needs, except for students with serious visual impairments that do not allow them to perform tasks with the help of personal computers, laptops and/or other technical means.*

Studying in a foreign language. *In the course of the tasks, students may be recommended to refer to English-language sources. Assigning incentive and penalty points According to the Regulation on the system of evaluation of learning results, the sum of all incentive points cannot exceed 10% of the rating scale.*

All students must attend lectures and practical classes, where you need to actively work on learning the learning material. For objective reasons (for example - illness, international internship), training can take place in an online form individually upon agreement with the head of the course.

Deadlines and Rescheduling Policy:

Works that are submitted late without good reason will be assigned a lower grade. Rearranging modules takes place with the permission of the dean's office if there are good reasons (for example, sick leave).

***Policy on academic integrity** :*

All written works are checked for plagiarism and accepted for defense with correct textual borrowings of no more than 20%. Write-offs during control work are prohibited (including using mobile devices).

8. Types of control and rating system of assessment of learning outcomes

During the semester, students perform 8 computer workshops. The maximum number of points for each computer workshop: 6 points.

Points are awarded for:
- quality of performance of the computer workshop: 0-2 points;
- answer to theoretical questions during the defense of the computer workshop: 0-2 points;
- timely presentation of work for defense: 0-2 points.

Performance evaluation criteria:
2 points – the work is done qualitatively, in full;
1 point - the work is completed in full, but contains minor errors;
0 points – the work is incomplete or contains significant errors.

Answer evaluation criteria:
2 points – the answer is complete, well-argued;
1 point – the answer is generally correct, but has flaws or minor errors;
0 points - there is no answer or the answer is incorrect.

Criteria for evaluating the timeliness of work submission for defense:
2 points – the work is presented for defense no later than the specified deadline;
0 points – the work is submitted for defense later than the specified deadline.

The maximum number of points for performing and defending computer practicals:
6 points × 8 comp. practice = 48 points.

*The assignment for **the modular test** consists of 3 questions - 1 theoretical and 2 practical. The answer to a theoretical question is worth 6 points, and the answer to a practical question is worth 10 points.*

Evaluation criteria for each theoretical test question:
6 points – the answer is correct, complete, well-argued;
5 points – the answer is correct, detailed, but not very well argued;
4 points - in general, the answer is correct, but has shortcomings;
3 points – there are minor errors in the answer;
1-2 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

Evaluation criteria for the practical test question:
9-10 points – the answer is correct, the calculations are completed in full;
7-8 points - the answer is correct, but not very well supported by calculations;
5-6 points - in general, the answer is correct, but has flaws;
3-4 points – there are minor errors in the answer;
1-2 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

The maximum number of points for a modular control work:
*2 papers * (6 points × 1 theoretical question + 10 points × 2 practical questions) = 52 points.*

The rating scale for the discipline is equal to:

$R_c = R_{com.practice} + R_{MKR}$ = 48 points + 52 points = 100 points.

Calendar control: is carried out twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements.
At the first certification (7th week), the student receives "passed" if his current rating is at least 50% of the maximum number of points (20 points) that the student can receive before the first certification.
At the second certification (13th week), the student receives "passed" if his current rating is at least 50% of the maximum number of points (35 points) that the student can receive before the second certification.

*Semester control: **assessment***

Conditions for admission to semester control:
With a semester rating (R_C) of at least 60 points and the enrollment of all computer practical work, the graduate student receives credit "automatically" according to the table (Table of correspondence of rating points to grades on the university scale). Otherwise, he has to complete the credit control work.

Completion and protection of a computer workshop is a necessary condition for admission to the performance of credit control work.

A graduate student can try to improve his grade by writing a graded test, and his semester marks will be canceled ("hard" grading system).

The composition and evaluation criteria of the assessment test:

***The test task** consists of 4 questions - 2 theoretical and 2 practical. The answer to each theoretical and practical question is evaluated by 25 points.*

Evaluation criteria for each theoretical test question:
24-25 points – the answer is correct, complete, well-argued;
21-23 points – the answer is correct, detailed, but not very well argued;
17-20 points - in general, the answer is correct, but has flaws;
12-16 points – there are minor errors in the answer;
1-11 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

Evaluation criteria for the practical test question:
24-25 points – the answer is correct, the calculations are completed in full;
21-23 points - the answer is correct, but not very well supported by calculations;
17-20 points - in general, the answer is correct, but has flaws;
12-16 points – there are minor errors in the answer;
1-11 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

The maximum number of points for a modular control work:
25 points × 2 theoretical questions + 25 points × 2 practical questions = 100 points.

Table of correspondence of rating points to grades on the university scale :

Scores	Grade
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Fail
Admission conditions not met	Not Graded

9. Additional information on the discipline (educational component)

The list of questions submitted for semester control will be announced at the last class.

Work program of the academic discipline (syllabus):

Is designed by Ph.D., Assoc. Prof., Onai M.V.

Adopted by Computer Systems Software Department (protocol № 8, 22 January 2025)

Approved by the Methodical commission of the Faculty of Applied Mathematics (protocol № 8, 03 February 2025)