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

Department of Computing Technics

FUNDAMENTALS OF COMPUTER MODELLING

(Silabus)

Details of the discipline

Level of higher education ***First (bachelor's) level***

Field of expertise	*12 Information Technologies*
Speciality.	*123 Computer Engineering*
Educational programme	*Computer systems and networks*
Status of the discipline	*Selective*
Form of study	*Full-time (full-time), part-time*
Year of study, semester	*4th year, autumn semester*
Scope of the discipline	*4 credits 120 hours*
Semester control / control measures	*Test MCW*
Class schedule	*//rozklad.kpi.ua*
Language of instruction	*English*
Information about the course leader / lecturers	*Associate Professor of the Dept. Of Computing Technics Volokita Artem, artem.volokita@kpi.ua* Assistant of the Dept. *Of Computing Technics* Ivanishchev Bohdan, callidus.iv@gmail.com
Course location	//comsys.kpi.ua

Programme of the discipline

1. Description of the discipline, its purpose, subject matter and learning outcomes

The silhouette of the educational component "Fundamentals of Computer Modelling" is compiled in accordance with the educational programmes for bachelors in Computer Systems Software Engineering, Computer Systems Software Information Engineering in the specialty 121 Software Engineering and the EP "Computer Systems and Networks" in the specialty 123 Computer Engineering and the EP in the specialty 126 Information Systems and Technologies of the first (bachelor's) level of higher education in the field of knowledge 12 Information Technology.

The aim of the discipline is to strengthen students' professional competences:

- PC 2 Ability to use modern programming methods and languages to develop algorithmic and software
- PC 3 Ability to create system and application software of computer systems and networks
- PC 6 Ability to design, implement and maintain computer systems and networks of various types and purposes
- PC 9 Ability to systematically administer, use, adapt and operate available information technologies and systems
- PC 11 Ability to prepare the obtained work results in the form of presentations, scientific and technical reports.

- PC 12 Ability to identify, classify and describe the operation of software and hardware, computer and cyber-physical systems, networks and their components using analytical and modelling methods.
- PC 13 Ability to solve problems in the field of computer and information technology, to identify the limitations of these technologies
- PC 15 Ability toargue the choice of methods for solving specialised problems, critically evaluate the results obtained, justify and defend the decisions made.

The subject of the discipline is methods and tools for analytical and simulation modelling of dynamic processes. The credit module is designed to provide training for future bachelors in the use of computer technology for numerical modelling of processes and systems that are of professional interest.

Programme learning outcomes, the formation and improvement of which is aimed at the discipline:

- PLO 2 Have skills in conducting experiments, data collection and modelling in computer systems.
- PLO 3 Know the latest technologies in the field of computer engineering.
- PLO 6 To be able to apply knowledge to identify, formulate and solve technical problems of the speciality, using methods that are most suitable for achieving the goals
- PLO 11 Be able to search for information in various sources to solve computer engineering problems.
- PLO 16 Be able to evaluate the results obtained and defend the decisions made with reasons

2. Prerequisites and post-requisites of the discipline

For successful mastering of the discipline, it is desirable for the student to have the following educational components: "Programming", "Object-oriented programming", "Discrete mathematics", "Probability theory", "Data structures and algorithms", "Algorithms and methods of computing".

The competences, knowledge and skills acquired in the course of studying the educational component can be used for further study of the educational components: "Pre-diploma practice", "Diploma design".

3. Content of the discipline

Chapter 1. Objectives, methods and modelling process.

Topic 1.1. The concept of a model.

Topic 1.2. Modelling tasks.

Topic 1.3. Modelling methods.

Topic 1.4. The process of modelling.

Section 2. Methods of collecting information and data about the system.

Topic 2.1. Identification of the law of distribution.

Topic 2.2. Approximation of functional dependence.

Chapter 3. Formalisation of the processes of functioning of discrete systems.

Topic 3.1. Massive service networks.

Topic 3.2. Petri nets.

Chapter 4. Analytical modelling.

Topic 4.1: Analytical modelling of queuing networks.

Topic 4.2: Analytical study of the properties of Petri nets.

Chapter 5. Simulation modelling.

Topic 5.1. Generators of random variables.

Topic 5.2. Algorithms for simulating the processes of functioning of discrete systems.

Topic 5.3. Simulation modelling of a queuing network.

Topic 5.4. Simulation modelling of the Petri net.

Chapter 6. Methods of studying simulation models.

Topic 6.1. Planning and conducting factorial experiments.

Topic 6.2. Regression analysis of the influence of factors.

Topic 6.3. Analysis of variance of the influence of factors.

Chapter 7. Methods of optimising simulation models.

Topic 7.1. Finding optimal values using a series of factorial experiments.

Topic 7.2. Methods of group consideration of arguments.

Topic 7.3. Evolutionary methods for finding optimal values.

Chapter 8. Software for simulation modelling of systems.

Topic 8.1. GPSS simulation modelling language.

Chapter 9. Methods of self-organisation of models.

Topic 9.1. Basic concepts of the theory of self-organisation of models.

Topic 9.2. Algorithms for self-organisation of models.

4. Training materials and resources

Main literature

1. LInge S., Petter H. Programming for computations. Python: A Gentle Introduction to Numerical Simulations with Python 3.6. SpringerOpen, 2019. - 355 p.

2. Virk R. The Simulation Hypothesis: An MIT Computer Scientist Shows Why AI, Quantum Physics and Eastern Mystics All Agree We Are In a Video Game Tapa blanda – Ilustrado, 2019.- 330 p.

Further reading

3 Ciaburro G. Hands-On Simulation Modeling with Python: Packt Publishing 2022.- 346 p.

Educational content

5. Methods of mastering the discipline (educational component)

Lecture classes

№	Title of the lecture topic and a list of key questions (list of teaching aids, links to information sources)
1	**Chapter 1. Objectives, methods and modelling process.** **Lecture 1: Objectives, methods and process of modelling.** Main issues: The concept of a model, methods of building and classification of models. Tasks and methods of modelling, modelling process, systematic approach to model building. Video of the lecture: https://bbb.comsys.kpi.ua.
2	**Section 2. Methods of collecting information and data about the system.** **Lecture 2: Identification of the law of distribution.** Main issues: Formation of an array of values of a random variable. Building a frequency histogram. Formation of a hypothesis about the type of distribution law. Estimating the values of the parameters of the distribution law. Checking compliance with the criterion of agreement.

	Video of the lecture: https://bbb.comsys.kpi.ua.
3	**Section 2. Methods of collecting information and data about the system.** **Lecture 3: Functional dependence approximation.** Main issues: Formation of an array of observed values. Formation of a hypothesis about the type of functional dependence. Estimation of the values of the parameters of functional dependence. Correlation and regression analysis of functional dependence. Video of the lecture: https://bbb.comsys.kpi.ua.
4	**Chapter 3. Formalisation of the processes of functioning of discrete systems.** **Lecture 4. Massive service networks.** Main issues: Elements of a queuing network. Multiservice networks with route blocking. Video of the lecture: https://bbb.comsys.kpi.ua.
5	**Chapter 3. Formalisation of the processes of functioning of discrete systems.** **Lecture 5. Petri nets.** Main issues: Elements of a Petri net. Petri nets with time delays. Petri nets with conflicting transitions. Petri nets with multichannel transitions. Petri nets with information links. Video of the lecture: https://bbb.comsys.kpi.ua.
6	**Chapter 4. Analytical modelling.** **Lecture 6. Analytical modelling of open queuing networks.** Main issues: Formation of a set of input data. Calculation of transmission coefficients. Checking the steady state condition. Calculation of normalising factors for the CMO. Determination of functions that set the probability of finding requirements in the CMO. Calculation of performance indicators of the queuing network. Analysis of the obtained modelling results. Video of the lecture: https://bbb.comsys.kpi.ua.
7	**Chapter 4. Analytical modelling.** **Lecture 7. Analytical modelling of closed queuing networks.** Main issues: Formation of a set of input data. Calculation of transmission coefficients. Calculation of the normalising factor for the MoD network. Determination of auxiliary functions for the CMO. Determination of functions that specify the probability of finding requirements in the CMO. Calculation of performance indicators of the queuing network. Analysis of the obtained modelling results. Video of the lecture: https://bbb.comsys.kpi.ua.
8	**Chapter 4. Analytical modelling.** **Lecture 8. Analytical study of the properties of Petri nets.** Main issues: Matrix approach to studying the properties of Petri nets. Reachability tree as a way to study the properties of Petri nets. Video of the lecture: https://bbb.comsys.kpi.ua.
9	**Chapter 5. Simulation modelling.** **Lecture 9. Generators of random variables.** Main issues: Generating a random variable using the inverse function method. Using the inverse function method to generate a discrete random variable. The tabular method of generating a random number. Video of the lecture: https://bbb.comsys.kpi.ua.
10	**Chapter 5. Simulation modelling.**

	Lecture 10. Simulation modelling of a queuing network. Main issues: Algorithm for advancing model time. Algorithm for advancing the model state as a function of time. Algorithm for collecting information about the model's behaviour during the simulation process. Video of the lecture: https://bbb.comsys.kpi.ua.
11	**Chapter 5. Simulation modelling.** **Lecture 11: Simulation modelling of Petri nets.** Main issues: Simulation modelling of a Petri net with time delays. Simulation modelling of a Petri net with conflict transitions. Simulation modelling of a Petri net with multichannel transitions. Video of the lecture: https://bbb.comsys.kpi.ua.
12	**Chapter 6. Methods of studying simulation models.** **Lecture 12. Planning and conducting factorial experiments.** Main issues: Strategic planning of factorial experiments. Determination of the duration of one run. Determination of the number of runs. Video of the lecture: https://bbb.comsys.kpi.ua.
13	**Chapter 6. Methods of studying simulation models.** **Lecture 13. Regression analysis of the influence of factors.** Main issues: Construction of the planning matrix. Statistical processing of the results of factorial experiments. Video of the lecture: https://bbb.comsys.kpi.ua.
14	**Chapter 6. Methods of studying simulation models.** **Lecture 14. Analysis of variance of the influence of factors.** Main issues: One-factor experiment in the case of qualitative factors. Multivariate experiment in the case of qualitative factors. Video of the lecture: https://bbb.comsys.kpi.ua.
15	**Chapter 7. Methods of optimising simulation models.** **Lecture 15. Methods of optimising simulation models.** Main issues: Finding optimal values using a series of factorial experiments. Methods of group consideration of arguments. Evolutionary methods of finding optimal values. Video of the lecture: https://bbb.comsys.kpi.ua.
16	**Chapter 8. Software for simulation modelling of systems.** **Lecture 16. Software for simulation modelling of systems.** Main issues: GPSS simulation modelling language. Examples of problem solving. Video of the lecture: https://bbb.comsys.kpi.ua.
17	**Chapter 9. Methods of self-organisation of models.** **Lecture 17. Basic concepts of the theory of self-organisation of models.** Main issues: The principle of self-organisation of models. External criteria for model selection. Determination of model parameters from the training sequence data. Video of the lecture: https://bbb.comsys.kpi.ua.
18	**Chapter 9. Methods of self-organisation of models.** **Lecture 18. Algorithms for self-organisation of models.** Main issues: Single-row (combinatorial) algorithms for self-organisation of models. Multi-row

	(threshold) algorithms for self-organisation of models. Noise immunity of the self-organisation algorithm. Video of the lecture: https://bbb.comsys.kpi.ua.

Test

The purpose of the tests is to consolidate and test theoretical knowledge of the educational component, to acquire practical skills in solving problems independently and in compiling and compiling programmes.

The T1 test is performed after studying sections 1-4.

The T2 test is taken after studying Chapters 5 to 9.

Laboratory *work*

The purpose of the laboratory cycle is to provide students with the necessary practical skills to develop and research methods and tools for computer modelling of dynamic processes.

Laboratory work includes:

- setting the input task,
- theoretical information on methods and means of solving the problem,
- analysis of mathematical and algorithmic support,
- justification of the choice of research software,
- results of model experiments,
- interpretation of the modelling results and conclusions
- listing of the programme.

№	List of laboratory works.
1	**Laboratory work 1:** Checking the random number generator for compliance with the law of distribution.
2	**Laboratory work 2.** Identification of an object based on observation data.
3	**Laboratory work 3.** Study of the MoD network by simulation methods. Development of a simulation algorithm and its implementation.
4	**Laboratory work 4.** Study of the Petri net by simulation methods. Creating a simulation algorithm and its implementation.
5	**Laboratory work 5.** Planning and conducting machine experiments with a simulation model of the system.
6	**Laboratory work 6:** Finding a model of optimal complexity using methods of model self-organisation.

Independent work of the student

No. s/n	Type of independent work	Number of hours
1	Preparation and execution of laboratory work	48
2	Preparation for tests. Study of lecture material and additional sources.	18
	Total hours	66

6. Policy of the discipline (educational component)

The following factors are taken into account when crediting and grading laboratory work:

- Completeness of the laboratory work assignment according to the individual option;
- Timeliness of laboratory work according to the schedule;
- Independence of laboratory work and no signs of plagiarism;
- Answers to questions about the content of laboratory work during its defence.

The following are taken into account in the assessment of test papers:

- Correctness and completeness of tasks;
- The number of tasks completed in a limited amount of time;
- Independence of assignments and no signs of plagiarism;
- The number of attempts to complete the tests.

To prepare for the tests, students receive a list of theoretical questions and the content of typical tasks that will be in the tests.

For the first and second attestation, the number of laboratory works credited at the time of the attestation is taken into account.

Policy on academic integrity: Code of Honour of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behaviour and provides for a policy of academic integrity.

7. Types of control and rating system for assessing learning outcomes

Current control: exercises in lectures, testing, performance and defence of laboratory works, module tests.

Calendar control: carried out twice a semester as a monitoring of the current state of implementation of the silabus requirements.

Semester control: credit.

Conditions for admission to semester control: completed and defended laboratory work.

Table of correspondence between rating points and grades on the university scale:

Number of points	***Assessment.***
100-95	*Excellent*
94-85	*Very good*
84-75	*Good.*
74-65	*Satisfactory*
64-60	*Enough is enough*
Less than 60	*Unsatisfactory*
The conditions for admission are not met	*Not allowed*

The overall rating of the student after the end of the semester consists of the points received for: completion and defence of laboratory work (LW1-LW6), completion of T1 and T2.

Laboratory work

Weighting. Laboratory works LW1-6 have a weighting score of 10.

Six labs are scheduled for independent completion. The topics of laboratory work are coordinated in time and content with the topics of lectures. Completion of laboratory work in full allows you to acquire practical skills. The teacher assigns individual practical tasks for each laboratory work, which are

performed by each student personally. Students can also complete an extended additional task to gain extra points.

Assessment criteria: The basic version is worth 6 points, with the defence of an additional practical task worth up to 10 points.

Modular tests

Weighting. Two tests have a weighting of 20 each.

Two module control works (T1, T2) are planned to be completed during the calendar control (assignments are issued a week before the start of the calendar control). By agreement with the students, the deadlines for completing the T1 and T2 may be extended.

Assessment criteria: The assignments for T1 and T2 contain points for the relevant questions. The student chooses the questions to answer independently.

Additional (bonus) points

No extra points are provided.

Penalty points

There are no penalty points.

Calendar control

The calendar control is based on the current rating assessment. The condition for a positive assessment is that the student's current rating is at least 30% of the maximum possible at the time of the assessment. The score required for a positive calendar control is communicated to students by the teacher no later than 2 weeks before the start of the calendar control.

Form of semester control. Credit.

The student's semester rating is made up of the points he or she receives for the types of work, respectively.

Assessment of individual types of student's academic work (in points)

Type of academic work	Total by type of work
Performing and defending laboratory work LW1-6	60
Performing T1	20
PerformingT2	20
Rating for the semester	100
Test	30

A prerequisite for a student to be admitted to the automatic test is their individual semester rating of at least 60 points and completed LW1-6. If these requirements are not met, the student is not allowed to take the test. In order to improve the grade, it is allowed to rewrite T1, T2 and retake LW1-6.

8. Additional information on the discipline (educational component)

As part of the study of the discipline, it is allowed to credit points obtained as a result of distance courses on the Coursera platform, subject to prior approval of the course programme with the teacher and subject to obtaining an official certificate (if possible free of charge). Points for courses with only test assignments are counted in the number of hours of at least 60, and with a score of 30 (instead of

LW1-LW6). Thus, the maximum score is limited to 70 (including tests). If the courses have a practical part, reports from the practical parts can be counted as laboratory work, in which case the maximum score is limited to 100.

Work programme of the discipline (syllabus):

Compiled by assistant of the dept. Bohdan Ivanishchev, assistant of the Department of OT.

Approved by the Department of Computer Science (Minutes No. 10 of 25.05.2022).

Approved by the Methodological Commission of the Faculty (Minutes No. 10 of 9.06.2022).

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