MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
ODESSA I.I. Mechnikov NATIONAL UNIVERSITY
Department of mathematical support of computer systems

"APPROVED"
Vice-rector for scientific and pedagogical work
_____
"____" _____ 20___

WORKING PROGRAM OF EDUCATIONAL COURSE

OK3 "Information processes modeling methods in complex systems"
(course name)

Level of higher education Second (master's)

Field of knowledge 12 – Information technologies

Specialty 126 – Information systems and technologies
(code and name of specialty)

Educational and professional program Information systems and technologies
(EPP/ESP name)

Working program of the study course "Information processes modeling methods in complex systems". – Odesa: ONU, 2022. – 12 p.

Developers:
Rachynska A.L., PhD (Physics and Mathematics), Associate Professor
Palii K.S., lecturer

The work program was approved at the meeting of the department

mechanics, automation and information technologies

Protocol No. 1 of "16" 08 2022

Head of the department _____ (Alla RACHINSKA)
(signature)

Agreed with the OPP guarantor

"INFORMATION SYSTEMS AND TECHNOLOGIES"

_____(Eugene MALAKHOV)
(signature)

Approved by the Educational and Methodological Commission (EMC)

from information technologies

Protocol No. 1 of "31" 08 2022

Head of EMC _____ (Alla RACHYNSKA)
(signature)

Reviewed and approved at the department meeting

mechanics, automation and information technologies

Protocol No. 1 dated "28" 08 2023

Head of Department _____( )
(signature)

Reviewed and approved at the department meeting

mechanics, automation and information technologies

Protocol No.____ dated "____" _____202_

Head of Department _____( )
(signature)

1. Course description

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">Field of knowledge, specialty, specialization, level of higher education</td><td colspan="2">Characteristics of the academic discipline</td></tr>
<tr><td>full-time education</td><td>external form of education</td></tr>
<tr><td rowspan="15">The total number of:

credits - 4

hours - 120

content modules - 3</td><td rowspan="15">Branch of knowledge
12 Information technologies
(code and name)

Specialty
126 Information systems and technologies
(code and name)

Specializations:
_____
(name)

Level of higher education:
Second (master's)</td><td colspan="2">Mandatory</td></tr>
<tr><td colspan="2">Year of preparation:</td></tr>
<tr><td>1st</td><td>1st</td></tr>
<tr><td colspan="2">Semester</td></tr>
<tr><td>1st</td><td>1st</td></tr>
<tr><td colspan="2">Lectures</td></tr>
<tr><td>14 hours</td><td>8 hours</td></tr>
<tr><td colspan="2">Practical, seminar</td></tr>
<tr><td>hours</td><td>hours</td></tr>
<tr><td colspan="2">Laboratory</td></tr>
<tr><td>16 hours</td><td>6 hours</td></tr>
<tr><td colspan="2">Independent work</td></tr>
<tr><td>90 hours</td><td>106 hours</td></tr>
<tr><td colspan="2">Final control form:
exam</td></tr>
</table>

2. The purpose and tasks of the educational discipline

Goal

The purpose of teaching the discipline "Methods of modeling information processes in complex systems" is to form students' complex of scientific knowledge on the most complex issues of mathematical modeling of complex systems. Essentially important in the theory of mathematical modeling is the constant coordination of all aspects of building a model with the tasks and goals of research. This course focuses on some features of mathematical modeling of mechanical systems and processes that are essential for research.

Tasks:

Methodical: promote the mastery of methods of scientific knowledge and conducting generalizations of the materials of the most complex issues of mathematical modeling.

Practical: promote the formation of skills and abilities to analyze and generalize theoretical and practical materials on mathematical modeling of mechanical systems and processes.

The process of studying the discipline is aimed at forming elements of the following competencies:

a) General competences:

GC01. Ability for abstract thinking, analysis, and synthesis.

b) Special (professional, subject) competencies:

SC03. The ability to design information systems considering their purpose, incomplete or insufficient information, and conflicting requirements.

SC04. The ability to develop mathematical, informational, and computer models of objects and processes related to informatization.

SCM02. The ability to solve physics-mathematics problems related to modeling natural phenomena or technological processes using modern computer methods.

SCM05. The ability to model the architecture, behavior, and operational processes of specialized, autonomous, and distributed intelligent systems for automated information search and analysis.

Program learning outcomes:

LO04. Manage complex, unpredictable processes related to the development, implementation, and operation of ICT, requiring new strategic and team approaches.

LO06. Justify the selection of technical and software solutions, considering their interaction and potential impact on solving organizational problems, and organize their implementation and use.

LO08. Develop models of information processes and systems of different classes, using methods of modeling, formalization, algorithmization, and model implementation using modern computer tools.

LOM06. Develop mathematical models and software-information systems to solve current problems of multimedia information analysis and processing.

As a result of studying the academic discipline, the student should

know: the methodology of building mathematical models of mechanical processes and systems; how to use programming languages, information resource description languages, specification languages, tools during the design and creation of information

systems; how to carry out research work in the field of theoretical informatics and applied mathematics during the development of new information technologies.
be able: process the obtained results, analyze, interpret and present them, substantiate the proposed solutions at the modern scientific and technical level; programmatically implement algorithms for solving problems, develop system and application software for information systems and technologies; build mathematical models based on experimental and statistical data; apply the knowledge and skills acquired during training to conduct scientific and applied research, present and publish its results.

3. Content of the academic discipline

Content module 1. Models and simulations.

Topic 1. The concept of modeling. Examples of models.
Abstractions. Phenomena and objects. Models and simulations. Modeling concept.

Topic 2. Modeling of systems and processes.
Stages of modeling. Checking the adequacy of the model. Classification of models.

Topic 3. Mathematical modeling methodology.
Problems and goals of mathematical modeling. Mathematical description of interaction of model parameters. Methods of calculating initial parameters.

Topic 4. Mathematical models and their types.
Classification of mathematical models. Calculated mathematical models. Appropriate mathematical models. Similar mathematical models. Linear and non-linear models. Stationary and non-stationary models. Continuous and discrete mathematical models. Deterministic and stochastic models.

Content module 2. Modeling the complex movement of a material point

Topic 1. Motion of a material point in a perfectly smooth tube. Analytical and numerical modeling.
Development of a deterministic mathematical model of the movement of a material point in a perfectly smooth tube. Functional relationships of the model. Calculation methods of the obtained model. General analytical solution. Numerical simulation of movement and comparative analysis of the obtained results. Analysis of model input parameters.

Topic 2. Modeling the complex movement of a material point along a rough tube.
Development of a deterministic mathematical model of the movement of a material point along a rough tube. Functional relationships of the model. Calculation methods of the obtained model. Numerical modeling of motion and analysis of output parameters for different values of input parameters.

Topic 3. Modeling the complex movement of a material point in an environment with resistance.
Development of a deterministic mathematical model of the movement of a material point in an environment with resistance. Functional relationships of the model for different environments. Numerical simulation of movement, analysis of output parameters for different values of input parameters and comparative analysis of the obtained results for different models.

Topic 4. Modeling of the complex movement of a material point with non-uniform rotation of the plate.
Development of a deterministic mathematical model of the movement of a material point during non-uniform rotation of the plate. Functional relations of models for different laws of plate rotation. Numerical simulation of movement, analysis of output parameters for different values of input parameters and comparative analysis of the obtained results for different models.

Content module 3. Modeling of processes and systems in dimensionless form.

Topic 1. The equation of complex motion of a material point in dimensionless form.
Selection of characteristic parameters of the model. Dimensioning of the equations of motion of a material point along a rough tube taking into account resistance forces during uneven rotation of the plate.

Topic 2. Modeling the complex movement of a material point in dimensionless form.
Numerical study of the obtained mathematical model. Analysis of the obtained results. Analysis of model input parameters.

Topic 3. Modeling the flat area of process parameter selection.
Criteria for selecting model parameter values. Implementation of the process of modeling the flat region of parameter selection. Analysis of the obtained areas.

Topic 4. Modeling of the volume area of process parameter selection.
Realization of the modeling process of the volumetric area of parameter selection. Analysis of the obtained areas.

4. The structure of the academic discipline

Names of topics	Number of hours									
	Full-time					Correspondence form				
	That's all	including				That's all	including			
		l	p/s	lab	Wed		l	p/s	lab	Wed
1	2	3	4	5	6	7	8	9	10	11
Content module 1. Models and simulations										

Topic 1. Concept of modeling. Examples of models.	2.5	0.5			2	5.25	0.25			5
Topic 2. Modeling systems and processes.	3.5	0.5			3	5.25	0.25			5
Topic 3. Mathematical modeling methodology.	4.5	0.5			4	5.25	0.25			5
Topic 4. Mathematical models and their types.	5.5	0.5			5	5.25	0.25			5
Together according to content module 1	**16**	**2**			**14**	**21**	**1**			**20**
Content module 2. Modeling the complex movement of a material point										
Topic 1. Motion of a material point in a perfectly smooth tube. Analytical and numerical modeling.	16	2		4	10	16	2		2	12
Topic 2. Modeling of the complex movement of a material point along a rough tube.	16	2		4	10	15	2		2	11
Topic 3. Modeling the complex movement of a material point in an environment with resistance.	16	2		4	10	14	2		1	11
Topic 4. Modeling of the complex movement of a material point with non-uniform rotation of the plate.	16	2		4	10	16	1		1	14
Together according to content module 2	**64**	**8**		**16**	**40**	**61**	**7**		**6**	**48**
Content module 3. Modeling of processes and systems in dimensionless form										
Topic 1. The equation of complex motion of a material point in dimensionless form.	9	1			8	9				9
Topic 2. Modeling the complex movement of a material point in dimensionless form.	9	1			8	9				9

Topic 3. Modeling of the flat area of process parameter selection.	11	1			10	9				9
Topic 4. Modeling of the volumetric area of process parameter selection.	11	1			10	11				11
Together according to content module 3	**40**	**4**			**36**	**38**				**38**
Only hours	**120**	**14**		**16**	**90**	**120**	**6**		**6**	**106**

5. Topics of seminar classes

Not provided for in the curriculum

6. Topics of practical classes

Not provided for in the curriculum

7. Topics of laboratory classes

No s/p	Topic name	Number hours
1	Construction of a mathematical model of complex movement of a material point	1
2	Computer modeling of the complex movement of a material point using an analytical solution	1
3	Computer modeling of the complex movement of a material point using a numerical solution.	2
4	Comparative analysis of analytical and numerical solution models	2
5	Construction of a mathematical model of the complex movement of a material point taking into account the force of friction	2
6	Construction of a mathematical model of the complex movement of a material point taking into account the resistance of the medium	2
7	Construction of a mathematical model of complex motion of a material point for non-uniform rotation	2
8	Modeling of connection forces during the movement of a material point along a tube	2
9	Construction of a mathematical model of complex movement of a material point taking into account the forces of friction, resistance and non-uniform movement of a material point	2
	Together	**16**

8. Independent work

No s/p	Title of the topic/types of tasks	Number hours
1	Complex motion of a material point/[1]	10

2	The Runge-Kutta method for solving a system of differential equations/[1]	10
3	Relative and absolute error /[1]	4
4	Using the plotting component/[1]	6
5	Models of medium resistance in mechanical processes/[1]	6
6	Models of non-uniform motion of a rigid body in mechanical processes/[1]	6
7	Characteristic parameters of the mathematical model of the mechanical process/[1]	10
8	Use of 2-D graphics in the modeling process/[1]	18
9	Use of 3-D graphics in the modeling process/[1]	20
	Together	**90**

9. Teaching methods

Verbal: lectures with analysis of specific examples, consultations.
In person: illustration of material in the form of multimedia presentations.
Practical: laboratory work.

10. Forms of control and evaluation methods

Methods of current/periodic control: evaluation of the performance of laboratory work.
Final control: Exam. During the final examination, the student must answer theoretical questions.

Evaluation criteria at the final inspection:
Perfectly: The answer should be complete and short. It should not contain material that does not relate to the essence of the question. Formulate statements clearly, skillfully apply the necessary ones.
Fine: Small flaws, inaccuracies in the presentation of the material. There are gaps in the substantiation of statements.
Satisfactorily: Answers have false statements.
Unsatisfactorily: Ignorance and misunderstanding of the main idea of the theoretical question.

11. Questions for final control

1. What is a system model?
2. What models do you know?
3. What are the model classifications?
4. What are the methods of building models?
5. What models are called physical?
6. What are the modeling methods?

7. What is meant by analytical modeling? simulation modeling? mathematical modeling?
8. Formulate the formulation of the modeling problem.
9. Give the essence and characterize the task of the object research stage in modeling.
10. What are well-organized systems?
11. What is the model, how does it differ from the original?
12. What is modeling?
13. What types are models divided into according to the characteristic features of the expression of the properties of the original and the features of the model's functioning?
14. What are the types of models based on the basis for transforming the model's properties into the original model?
15. What is model adequacy testing?
16. State the essence and characterize the tasks of the model analysis stage.
17. What does the mathematical description of the model include?
18. How is the complex movement of a material point simulated?
19. What is the difference between analytical and numerical study of a problem?
20. How is the non-ideal tube surface modeled?
21. How is the resistance of the medium simulated?
22. What are the characteristic parameters of a mechanical process?
23. What is the meaning of dimensionless quantities?
24. Can a mechanical process be simulated for arbitrary problem parameters?
25. What restrictions can be set on the parameters of the complex motion model of a material point?
26. What analysis of the obtained results can be carried out?
27. What kind of comparative analysis was carried out in the works?
28. What are the differences between the various components of the bond reaction forces?
29. What inertial forces are modeled in the works?
30. What is the difference between models of uniform and non-uniform rotation of the plate?
31. What laws of motion of the plate give more realistic results?
32. How can you calculate the law of plate motion?
33. What other mathematical models can be designed for the problem of complex motion of a material point?
34. Give examples of the complex movement of a material point in life, in technology.
35. How many models were investigated in the works?
36. Which model in the works was the most realistic?
37. How many effective deterministic series were obtained in the works?
38. What output information best describes the system model?

39. What advantages of computer modeling do you see?
40. What prospects for computer modeling of complex systems do you see?

12. Distribution of points received by students

Content module No. 2					Final CONTROL (exam)	Total points
LR 1	LR 2	LR 3	LR 4	LR 5		
15	15	15	15	15	25	100

Evaluation scale: national and ECTS

The sum of points for all types of educational activities	ECTS assessment	Evaluation on a national scale	
		for an exam, course project (work), practice	for credit
90 - 100	**AND**	perfectly	counted
85-89	**IN**	fine	
75-84	**WITH**		
70-74	**D**	satisfactorily	
60-69	**IS**		
35-59	**FX**	unsatisfactory with the possibility of reassembly	not counted with the possibility of retaking
0-34	**F**	unsatisfactory with mandatory repeated study of the discipline	not enrolled with mandatory repeated study of the discipline

13. Methodological support

1. Electronic synopsis of lectures on the discipline "Methods of modeling information processes in complex systems" Classroom: https://drive.google.com/drive/folders/1IgmYtG-HDJOBaoheHlyerYEAe6RzjGyy?usp=sharing
2. Laboratory works in the discipline "Methods of modeling information processes in complex systems" Classroom: https://drive.google.com/drive/folders/1IgmYtG-HDJOBaoheHlyerYEAe6RzjGyy?usp=sharing

14. Recommended literature

Basic literature

1. Tomashevskyi V. M. Modeling of systems: a textbook. Kyiv: VNV Publishing Group, 2005. 352 p.

2. Makhney O. V. Mathematical modeling: teaching. manual Ivano-Frankivsk: V. P. Suprun, 2015. 372 p.
3. Tomashevskyi V.N., Zhdanova O.G., Zholdokov O.O. Solving practical problems using computer modeling methods.: teaching. manual Kyiv: Korniychuk, 2001. 268 p.
4. Stetsenko I.V. Modeling of systems: training. manual Cherkasy: ChDTU, 2010. 399 p.
5. Theory of information processes and systems / O.V. Polonevych, V.R. Kosenko, K.P. Storchak, O.M. Tkalenko: teacher. manual Kyiv: DUT, 2018. 101 p.
6. Pavlovsky M.A. Theoretical mechanics: a textbook. Kyiv: Technika, 2002. 511 p.
7. Kinematics and dynamics of a point. Computer course: textbook / M.A. Pavlovsky and others. Kyiv: Lybid, 1993. 243 p.
8. Lyashchenko M. Ya., Golovan M. S. Numerical methods: a textbook. Kyiv: Lybid, 1996. 288 p.
9. Pavlenko P. M. Fundamentals of mathematical modeling of systems and processes: academic. manual Kyiv: NAU Book Publishing House, 2013. 201 p.

Auxiliary

1. Skeeter I.S., Tkalenko N.V., Trunova O.V. Mathematical methods of making managerial decisions: teaching. manual Chernihiv: ChDIEU, 2011. 250 p.
2. Lyashenko I.M., Korobova M.V., Stolyar A.M. Fundamentals of mathematical modeling of economic, ecological and social processes: teaching. manual Ternopil: Educational book - Bohdan, 2006. 304 p.
3. Fundamentals of system design and system analysis of complex objects: textbook / edited by V. I. Bykova. Kyiv: Lybid, 2000. 270p.
4. Strutynsky V.B. Mathematical modeling of mechanical processes and systems: a textbook. Zhytomyr: ZHYTI, 2001. 612 p.
5. Mathematical programming: a study guide / A. F. Barvinskyi et al. Lviv: Lviv Polytechnic National University (Intellect+ Information and Publishing Center Institute of Postgraduate Education) "Intellect - West", 2004. 448 p.
6. Vitlinskyi V.V., Nakonechnyi S.I., Tereshchenko T.O. Mathematical programming: teaching method. self-help manual studied disc. Kyiv: KNEU, 2001. 248 p.
7. Computer modeling of systems and processes. Calculation methods: teaching. manual / R. N. Kvetny and others. ; Vinnytsia national technical Univ. Vinnytsia: VNTU, 2013. 191 p.