National Technical University of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

Department of Biomedical engineering
Faculty of Biomedical engineering

FUNDAMENTALS OF DISCRETE MATHEMATICS

Working program of the basic discipline (Syllabus)

Requisites of the discipline	
Cycle of Higher Education	***First cycle of higher education (bachelor degree)***
Branch of knowledge	*16 Chemical and bioengineering*
Specialty	*163 Biomedical engineering*
Educational program	*Medical engineering*
Status of the discipline	*Mandatory discipline*
Learning form	*Full-time (day-time)/ Full-time (part-time) /Distance/Mixed*
Semester	*Second year, autumn semesters*
Course scope	*4 ECTS credits / 120 hours*
Semester control / control measures	*Final Test, Module Test*
Schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language	*English*
Information about course supervisor and lecturers	***Lecturer:*** *Candidate of Physical and Mathematical Science, Associate Professor of BME Kateryna Hlynana, e-mail: glinkate@gmail.com, Viber - +380666333249* ***Practical:*** *Candidate of Physical and Mathematical Science, Associate Professor of BME Kateryna Hlynana, e-mail: glinkate@gmail.com, Viber - +380666333249*
Course placement	*Zoom*

Distribution of hours				
Semester	**Lectures**	**Practical**	**Laboratory**	**Self-study**
spring semester	*28*	*46*		*48*

Curriculum of the discipline

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

The purpose of the credit module

The purpose of the discipline "Fundamentals of discrete mathematics" to give fundamental knowledge of basics in widely applicable mathematical tools for computer science, including topics from set theory, combinatorics, probability theory, and graph theory and their usage in solving professional problems in the field of biomedical engineering.

The main purpose of the Course "Fundamentals of discrete mathematics" is to form students'

ability to apply mathematical methods in the analysis and modeling of different processes and systems.

Skills are required to study the Course:

-Basic knowledge of higher mathematics; ability to operate with basic mathematical objects such as numbers, sets, functions; ability to make logical conclusions.

General competencies (*OPP was put into effect by the Rector's Order NON / 89/2021 of 19.04.2021****):***

GC 1 *- Ability to apply knowledge in practical situations.*

GC 2 *- Knowledge and understanding of the subject area and understanding of professional activity.*

GC 4 *- Skills in the use of information and communication technologies.*

GC 7 *- Ability to generate new ideas (creativity).*

GC 8 *- Ability to make well-grounded decisions.*

Special (professional) competencies *(OPP was put into effect by the Rector's Order NON / 89/2021 of 19.04.2021):*

PC 6 *- Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services.*

PC 12 *- Ability to develop, plan and apply mathematical methods in the analysis, modeling of the functioning of living organisms, systems and processes in biology and medicine*

The program learning outcomes *after studying the discipline "Analog and digital circuitry" are (OPP put into effect by the Order of the Rector NON / 89/2021 from 19.04.2021):*

PLO 24 *- Apply knowledge of the basics of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, resistance and strength of materials, properties of gases and liquids, electronics, computer science, obtaining and analyzing signals and images, automatic control, systems analysis and decision making methods at the level required to solve the problems of biomedical engineering.*

PLO 25 *- Formulation of logical conclusions and substantiation of recommendations for evaluation, operation and implementation of biotechnical, medical-technical and bioengineering means and methods*

2 Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The academic discipline "Fundamentals of discrete mathematics" refers to the cycle of professional training and has an interdisciplinary nature. It integrates according to its subject knowledge from other disciplines: " Engineering and computer graphics", " Fundamentals of computer science", " Higher mathematics ". According to the structural and logical scheme of the training program, the discipline " Fundamentals of discrete mathematics " is the basis for the study of disciplines " Object-oriented programming" and in further practical work in the specialty.

3 Course Overview

The main parts and subjects that will be considered in the process of studying the course:

Section 1. Combinatorics and discrete probability theory

Subject 1.1. Set theory
Subject 1.2. Counting methods in combinatorics
Subject 1.3. Random experiment. Probability.
Subject 1.4. Conditional probability
Subject 1.5. Law of total probability
Subject 1.6. Bayes' formula. Diagnostic test
Subject 1.7 Discrete random variables
Subject 1.8. Joint distribution of two random variables. Conditional distribution.
Subject 1.9. Expectation and Variance of random variables

Section 2. Graph theory

Subject 2.1. Graph theory: basic definition and examples.
Subject 2.2. Representation of graphs. Paths and circuits.
Subject 2.3. Graph Traversal and Shortest path.
Subject 2.4. Flows and cuts. Maximum flow and minimum cuts theorem.
Subject 2.5. Trees. Spanning trees.
Subject 2.6. Coloring Graph. Planar graphs

4. Coursebooks and teaching resources

Basic literature:

1. *Ross Sh. M. Topics in Finite and Discrete Mathematics – Cambridge Unversity Press, -2000 – 265p.*
2. *Goodaire E.G., Parmenter M.M. Discrete Mathematics with Graph Theory - Prentice Hall, 2001. - 538 p*
3. *Raluca Balan, Gilles Lamothe, Expect the Unexpected – 2nd ed. – World Scientific Publishing, 2017 – 302 p.*

Additional literature:

1. *Lovasz L., Pelikan J., Vesztergombi K. Discrete Mathematics, 2003, - 290 p.*
2. *Miklos Bona, A Walk Through Combinatorics: An Introduction to Enumeration and Graph Theory, - 3rd ed., World Scientific Publishing, 2011 – 546 p.*
3. *Roberts, Fred S. Applications of Combinatorics and Graph Theory to the Biological and Social Sciences, - Springer, 1989, - 345 p.*

Educational content

5 Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
Spring semester, 4 ECTS credits / 120 hours				
1.	Set theory	PLO 24 PLO 25	Practical work 1	1st – 2nd week
2.	Counting methods in combinatorics.	PLO 24 PLO 25	Practical work 2 Quiz 1	3rd week

3.	Random experiment. Probability	PLO 24 PLO 25	Practical work 3 Quiz 2	4th week
4.	Conditional probability	PLO 24 PLO 25	Practical work 4	5th week
5.	Law of total probability.	PLO 24 PLO 25	Practical work 5 Quiz 3	6th week
6.	Bayes' formula. Diagnostic test.	PLO 24 PLO 25 PLO 44	Practical work 6 Quiz 4	7th week
7.	Discrete random variables	PLO 24 PLO 25	Practical work 7 Quiz 5	8th week
8.	Joint distribution of two random variables. Conditional distribution	PLO 24 PLO 25	Practical work 8 Quiz 6	9th week
9.	. Expectation and Variance of random variables.	PLO 24 PLO 25	Practical work 9 Quiz 7	10th week
10.	Module Test	PLO 24 PLO 25	Module Test writing	11th week
11.	Graph theory: basic definition and examples	PLO 24 PLO 25	Practical work 10 Quiz 8	12th week
12.	Representation of graphs. Paths and circuits	PLO 24 PLO 25	Practical work 11 Quiz 9	13th week
13.	Graph Traversal and Shortest path.	PLO 24 PLO 25	Practical work 12	14th week
14.	Flows and cuts. Maximum flow and minimum cuts theorem.	PLO 24 PLO 25	Practical work 13	15th week
15.	Trees. Spanning trees	PLO 24 PLO 25	Practical work 14 Quiz 10	16th week
16.	Coloring Graph. Planar graphs	PLO 24 PLO 25 PLO 44	Practical work 15	17th week
17.	Final Test	PLO 24 PLO 25 PLO 44	Final Test Pass	18th week

6 Self-study

One of the main types of semester control during the mastering of the discipline "Biophysics" is the calculation and graphic work. Calculation and graphic work is performed following the requirements, within the period specified by the teacher.

The main purpose of calculation and graphic work is to solve a practical problem using the material learned during lectures and independent work, and practical skills gained in practical works. The teacher performs personal variant of the tasks for each student.

Approximate subject of calculation and graphic work:

1. *Application of the set theory in practice.*
2. *Calculation of number in combinations, repetitions and permutation in a practical problem.*
3. *Calculation of probabilities of random events.*
4. *Application of graph theory in practical questions.*
5. *Finding shortest path and maximum flow using graph theory*

Calculation and graphic work is evaluated by the following criteria: logic of the plan; completeness and depth of topic disclosure; reliability of the received data; reflection of practical

materials and results of calculations; correctness of formulation of conclusions of the received results and conclusions; design; substantiation of the student's own opinion on this issue in the form of a conclusion.

The deadline for submission of calculation and graphic work for verification: week 17 of study.

Calculation and graphic work is not tested for plagiarism, but must meet the requirements of academic integrity. In case of academic dishonesty, the work is canceled and not checked.

Policy and control

7 Policy of academic discipline (educational component)

Attendance policy

Attending classes

Attendance at lectures is optional. Attending practical classes is desirable. All works and activities are aimed at the students' compliance with the assessment rating requirements. A significant part of a student rating is formed through active participation in activities in practical classes. Therefore, skipping a practical class does not allow a student to get points in the semester rating. General assessment takes place according to a scheme of the agreed grading system. Expected learning outcomes, control measures and deadlines are announced to students in the first practical class.

Control measures missed

Missed control measures (defense of practical work) can be worked out during the next classes, (provided that the task is scheduled for the current lesson), or in consultations.

Skipped express tests/ quizzes cannot be completed.

Skipped Module Test can be worked out in consultations.

Violation of deadlines, penalty points and rewarding points

Rewarding points		*Penalty points**	
Criterion	*Weight points*	*Criterion*	*Weight points*
Practical work improvement	*1 point (for each practical work)*	*Untimely implementation of practical work*	*From -0.5 points to -5 points (depending on the delivery date)*
Online courses completed on the topics that are agreed with the teacher	*5 points*	*Untimely implementation of a Module Test*	*From -2 points to -20 points (depending on the construction period)*
Writing of abstracts, articles, participation in international, national and / or other events or competitions on the subject of the Course	*From 5 points to +10 points*		

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not accrued.*

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive education

The course "Fundamentals of discrete mathematics" can be taught to the most of students with special educational needs.

Distance learning

Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).

Performance of practical works is carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Teaching in a foreign language

Teaching in English is carried out only for foreign students.

At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.

8 Monitoring and grading policy

Grading system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Express control works / quizzes	15	1.5	10	15
2.	Active work on a practical classes	30	2	15	30
3.	Calculation and graphic work (CGW)	25	25	1	25
4.	Module Test (MT)	30	30	1	30

5.	Final Test[1]	100	100	1	100
	Total				100

In the final practical class of the course, students will add their rewarding points, if there are any, to the performance score, and /or subtract their penalty points if there are any, from the performance score, and in case it is in total higher than 60 points, they may either get their Pass or take the Final Test to improve their grade. If the grade for the Final Test is higher than the final performance grade, the student receives the grade based on the results of this Test. If the grade for the Test is lower, the final performance grade is cancelled and the student receives a grade based on the results of the Test.

Students whose final performance grade is 30-60 points have to take the Final Test in order to complete the course.

Students whose score is below 30 did not meet the requirements of the course and are not allowed to take the Final Test.

***Calendar control** (CC) is performed twice a semester as monitoring of the current state of compliance with syllabus requirements.*

The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.

Criterion			The first CC	The second CC
Deadline of calendar controls			8th week	14th week
Conditions for obtaining a positive calendar control	Current grade		≥ 24 points	≥ 40 points
	Execution of practical work	PW №№1-4	+	+
		PW №№5-8	-	+
	Express control works /quizzes	At least 4 of any lectures	+	-
		At least 8 of any lectures	-	+
	Module Test	Estimated MCW	-	+

In the case of a plagiarism or an academic poor quality during training the control measure is not credited.

Semester certification of students

Mandatory condition for admission to the test		Criterion
1	Current rating	RD ≥ 30
2	Obtaining a positive assessment for the performed calculation and graphic work	More than 6 points
3	All practical works are tested	More than 0 points
4	Writing at least 6 express tests / tests	More than 6 points

The results are announced to each student separately in the presence or remotely (by e-mail). It is also recorded in the "Electronic Campus" system.

Optional requirements for admission to closure:

1. *Active work during practical classes.*
2. *Positive result of the first and the second calendar control.*

[1] *Taken into account in the amount of the rating together with the grade for CGW in case the student has not scored 60 points per semester or he wants to improve his grade.*

3. *Attending of lectures.*

The final performance score or the results of the Final Test are adopted by university grading system as follows:

Number points	*Assessment on the university scale*
100-95	*Excellent / Відмінно*
94-85	*Very good / Дуже добре*
84-75	*Good / Добре*
74-65	*Satisfactory / Задовільно*
64-60	*Passed / Достатньо*
Less 60	*Unsatisfactory / Незадовільно*
The course requirements are not met	*Not allowed / Не допущено*

2. Additional information on the course (educational component)

The list of questions for preparation for modular control work, and also for preparation for credit is given in appendix 1.

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / quizzes, practical work).

Work program of the course (syllabus):

is developed by *Associate Professor of BME, Candidate of Physical and Mathematical Sciences, Kateryna Hlyniana.*

Approved by *the Department of Biomedical Engineering (protocol № ___ to _____)*

Approved by *the Methodical Commission of the Faculty of Biomedical Engineering (protocol № __ to _____)*

Appendix 1 to the syllabus of the course

"Fundamentals of discrete mathematics"

The list of questions for preparation for the Module Test,

And also for preparation for the Final test

1. *. Basic operations in set theory: union, intersection, complement*
2. *. DeMorgan's law*
3. *Cartesian product*
4. *Counting methods: Rule of sum and Rule of product*
5. *Principle of inclusion/exclusion*
6. *Permutation and Combination*
7. *Arrangements*
8. *Random experiment: Sample space and Random events*
9. *Probability in classical random experiment*
10. *Properties of probability*
11. *Definition of Conditional probability*
12. *Properties of conditional probability*
13. *Indepencency*
14. *Law of total probability*
15. *Bayes' formula*
16. *Diagnostic test*
17. *Discrete random variable*
18. *Probability mass function: definition, properties*
19. *Cumulative distribution function: definition, properties*
20. *Bernoulli random variable*
21. *Binomial random variable*
22. *Joint distribution of two random variables*
23. *Marginal distribution*
24. *Conditional distribution*
25. *Independency*
26. *Expectation*
27. *Variance*
28. *Graphs: definition and examples*
29. *Types of Graphs*
30. *Degree of a vertex. Properties of degree*
31. *Graph Isomorphism*
32. *Representation of a graph: adjacency matrix, incidence matrix, adjacency list.*
33. *Paths and Circuits. Definition and properties.*
34. *Euler Path and Circuits: main theorem.*
35. *Spanning tree*
36. *Depth first search algorithm*
37. *Breadth First Search*
38. *Shortest path by Dijkstra's Algorithm*
39. *Coloring graph: greedy algorithm*
40. *Greedy Coloring Theorem*
41. *Euler Characteristic*
42. *Planar graph. Theorem about coloring of planar graph*
43. *Flows and cuts*
44. *Maximum flow: state of problem and algorithm*
45. *Minimum cuts: state of problem and algorithm*
46. *Max flow – min cut theorem.*