KYIV NATIONAL UNIVERSITY OF
CONSTRUCTION AND ARCHITECTURE

MASTER

Chair of information technologies of design and applied mathematics

«APPROVE»
Faculty of automation and information technologies, Chairman of SMC
_____/ Oleksandr TERENTYEV /
«____» _____ 2025

WORKING PROGRAM OF THE EDUCATIONAL COMPONENT

MC03 «GRAPHIC INFORMATION TECHNOLOGIES AND COMPUTATIONAL GEOMETRY»

(Code and name of the educational component)

Code	name of specialty, educational program
F6	***Information systems and technologies***, ***«Information systems and technologies»***

Teaching language: English

Developer:

Yevhenii BORODAVKA, doctor of engineering science, professor

(name and surname, academic degree, rank) (signature)

The work program was approved at the meeting of the chair of information technologies of design and applied mathematics protocol № ***1*** of ***28 August 2025***

Acting Head of Chair ITDAM _____ Yevhenii BORODAVKA

(signature) (name and surname)

Approved by the educational program guarantor ***«Information systems and technologies»***

Guarantor of EP _____ Yevhenii BORODAVKA

(signature) (name and surname)

Considered at the meeting of the scientific-methodical commission of the specialty ***F6 «Information systems and technologies»***.
Protocol № ***1*** of ***29 August 2025***

EXTRACT FROM THE CURRICULUM PLAN FOR 2025-2026 EDUCATIONAL YEAR

Code	Name of specialty, educational program	Form of study: **full-time**											Form of control	Semester	Approval by the deputy dean of the faculty
		ECTS credits	Number of hours						Number of individual tasks						
			Total volume	Auditory				Individual work							
				Total	including:										
					lectures	laboratory	practical		CP	CW	CGW	Individual task			
F6	Information systems and technologies, «Information systems and technologies»	***5,0***	***150***	***60***	***30***	***30***	***-***	***90***	***-***	***1***	***-***	***-***	***Exam***	***1***	

Abstract. The purpose and tasks of the educational component

The goal of the educational component — acquisition by students of the specialty F6 "Information Systems and Technologies" theoretical knowledge and practical skills in the mathematical and algorithmic foundations of computational geometry in the design of construction objects, development of programs for creating geometric models and forming and outputting graphic documents in the process of computer aided design of architectural and urban planning objects, image recognition and their processing.

Prerequisites: math, basic programming, and computer graphics.

Link to the page of the electronic educational and methodological complex of the discipline: https://org2.knuba.edu.ua/course/view.php?id=886

Competencies of students in the educational program are developed through the assimilation of the educational component.

CODE	CONTENT OF COMPETENCE
Integral competence	
IC	Ability to address research and innovation challenges in the area of information systems and technologies.
General competences	
GC 01	Ability to think abstractly, analyze, and synthesize information.
GC 05	Ability to evaluate and ensure the quality of completed work.
Professional competences	
PC 04	Ability to create mathematical, informational, and computer models of objects and processes involved in informatization.
PC 09	Ability to develop BIM systems for designing construction projects.

The program results of students from the educational program are generated through the integration of the academic component

CODE	PROGRAM RESULTS
PR 06	Justify the selection of technical and software solutions by considering how they interact and their potential impact on addressing organizational problems. Organize their implementation and usage.
PR 07	Make informed decisions about design solutions and create a service-oriented information architecture for an enterprise (institution, organization, etc.).
PR 08	Develop models of information processes and systems of various types, utilizing methods of modeling, formalization, algorithm development, and implementing models using modern computer tools.
PR 11	Solve digital transformation problems in new or unknown environments based on specialized conceptual knowledge that includes modern scientific achievements in the field of information technology, research, and integration of knowledge from different fields.
PR 14	Develop graphical information systems with computational geometry algorithms.

COURSE CONTENT

Unit 1. Planar algorithms in computer graphics	
Lecture 1.	***Problems related to points and lines.***
Topic 1.	Line equation by two points.
Topic 2.	Relative location of lines and points.
Topic 3.	Line segments intersection.
Topic 4.	Line segment shadow.
Topic 5.	Point to line distance.
Lecture 2.	***Problems related to rectangles.***
Topic 1.	Intersection of rectangles.
Topic 2.	External hull of the union of rectangles.
Lecture 3.	***Problems related to polygons.***
Topic 1.	Polygon square computation.
Topic 2.	Point to polygon relation.
Topic 3.	Line segment cutting by an arbitrary convex polygon.
Lecture 4.	***Planar clipping.***
Topic 1.	Cohen-Sutherland algorithm.
Topic 2.	Cyrus-Beck algorithm.
Topic 3.	Liang-Barsky algorithm.
Lecture 5.	***Line drawing algorithms.***
Topic 1.	Digital Differential Analyzer (DDA).
Topic 2.	Bresenham's line algorithm.
Lecture 6.	***Convex hulls.***
Topic 1.	Planar convex hull algorithm.
Topic 2.	Graham scan algorithm**.**
Topic 3.	Jarvis march (Gift wrapping).
Topic 4.	Fast convex hull method.
Topic 5.	Convex hull approximation algorithm.
Lecture 7.	***Triangulations.***
Topic 1.	Greedy triangulation.
Topic 2.	Delaunay triangulation.
Topic 3.	Triangulation of polygons.
Unit 2. Curves, polygonal models, and image processing	
Lecture 8.	***Curve fitting.***
Topic 1.	Interpolation.
Topic 2.	Approximation.
Lecture 9.	***Surface modeling.***
Topic 1.	Bilinear surfaces.
Topic 2.	Bezier surfaces.
Topic 3.	B-spline surfaces.
Lecture 10.	***Polygon meshes.***

Topic 1.	Vertex-vertex meshes.
Topic 2.	Face-vertex meshes.
Topic 3.	Winged-edge meshes.
Lectureя 11.	***Geometric search.***
Topic 1.	Computation of points.
Topic 2.	Point localization
Lecture 12.	***Tree data structures.***
Topic 1.	K-D tree.
Topic 2.	Quadtree.
Topic 3.	R-tree.
Topic 4.	Z-ordered trees.
Lecture 13.	***Invisible lines and face removal.***
Topic 1.	Back faces cutting.
Topic 2.	Roberts's algorithm.
Topic 3.	Ray tracing method.
Topic 4.	Z-buffer method.
Topic 5.	Sorting algorithms.
Lecture 14.	***Image blurring.***
Topic 1.	Median filter.
Topic 2.	Box blur.
Topic 3.	Gaussian blur.
Lecture 15.	***Image sharpening and edge detection.***
Topic 1.	Convolution kernels for sharpening.
Topic 2.	Convolution kernels for edge detection.
Topic 3.	Canny edge detector.

Laboratory works

Below is a list of lab topics. Each task is assigned a certain number of hours. The maximum points available for each task depend on its difficulty.

#	TOPIC OF THE WORK	HOURS	POINTS
1.	Determining the relative location of two segments.	3	5
2.	Cohen-Sutherland algorithm implementation.	3	5
3.	Liang-Barsky algorithm implementation.	3	5
4.	DDA algorithm implementation.	3	5
5.	Bresenham's algorithm implementation.	3	5
6.	Gaussian blur algorithm implementation.	3	5
7.	Median filter algorithm implementation.	3	5
8.	Image sharpening algorithm implementation.	3	5
9.	Edge detection with Prewitt convolution kernel.	3	5
10.	Edge detection with Sobel convolution kernel.	3	5
Total		**30**	**50**

Course work

Below is a list of topics for coursework. Students have the right to propose their topic and complete it with the teacher's agreement. The result of the coursework is a program that implements the selected algorithm and graphically displays the result of its work. Some tasks are simpler, so the maximum score for them is ***90*** points.

#	TOPIC OF THE WORK	POINTS
1.	Program to convert explicit representation to a vertex list.	90
2.	Program to convert a list of vertices to a list of edges.	90
3.	Constructing a Bezier curve from 5 points.	90
4.	Constructing a 5-point curve interpolation using the Lagrange method.	90
5.	Constructing a 5-point curve interpolation using Newton's method.	90
6.	Cutting a line segment by an arbitrary convex polygon.	90
7.	Graham scan algorithm implementation.	100
8.	Jarvis march algorithm implementation.	100
9.	Greedy triangulation algorithm implementation.	100
10.	Triangulation of non-convex polygons on the plane.	100
11.	Constructing a Bezier curve from N points.	100
12.	Software implementation of a quad-tree with a demonstration of its operation.	100
13.	Implementation of Bresenham's algorithm for circle generation.	100
14.	Canny edge detector implementation.	100
15.	Construction of B-splines with the ability to select the vector type.	100
16.	Construction of a natural cubic spline from N points.	100
17.	Construction of a convex hull by the approximation method.	100
18.	Constructing an interpolation curve from N points using the Lagrange method.	100
19.	Constructing an interpolation curve from N points using Newton's method.	100
20.	Construction of a bilinear surface.	100

Hours distribution for the individual work of students

#	TITLE OF AN INDIVIDUAL WORK	HOURS
1.	Processing lecture materials.	5
2.	Preparation for laboratory work.	5
3.	Individual study of the topic "Surface Modeling".	5
4.	Individual study of the topic "Geometric search".	5
5.	Individual study of the topic "Removing invisible lines and faces".	10
6.	Completion of coursework.	30
7.	Exam preparation.	30
Total		**90**

Methods of control and evaluation of knowledge

An overall assessment is conducted by measuring learning outcomes in the form of intermediate (modular) and final control measures (tests, defense of individual work, etc.), by the requirements of both external and internal systems of quality assurance in higher education.

Academic Integrity Policy

Texts of individual assignments (including those performed in the form of presentations or other forms) may be checked for plagiarism. To defend an individual assignment, the originality of the text must be at least 70%. Exceptions include cases where applicants' publications are included in the materials of scientific conferences and other scientific collections that have already been checked for plagiarism.

Cheating during testing and other written surveys is prohibited (including using mobile devices). If cheating is detected on the part of the applicant, he will receive another assignment. In the event of repeated detection, an additional session will be scheduled to pass the test.

Attendance Policy

An applicant who missed a classroom lesson for valid reasons must present the teacher with a document certifying these reasons and submit it to the dean's office of the faculty.

For objective reasons (illness, international internship, scientific and scientific-practical conference (round table), etc.), training may take place online in agreement with the course leader.

Control methods

The primary forms of participation of Applicants in the educational process, subject to current control: speech at practical classes; addition, opposition to the speech, review of the speech; participation in discussions; analysis of primary sources; written assignments (tests, individual works in the form of essays); and other written works, designed by the requirements. Each course topic, assigned to lectures and practical classes, is worked out by Applicants in one form or another, as outlined above. Mandatory attendance at lectures, activity throughout the semester,

attendance/workout of all classroom classes, and performance of other types of work provided for by the curriculum for this educational component.

When assessing the level of knowledge of the Applicant, the following are subject to analysis:

- Characteristics of the answer: integrity, completeness, logic, justification, correctness;
- Quality of knowledge (degree of assimilation of factual material): meaningfulness, depth, flexibility, effectiveness, systematicity, generalization, strength;
- Degree of formation of the ability to combine theory and practice when considering situations and practical tasks;
- Level of mastery of mental operations: ability to analyze, synthesize, compare, abstract, generalize, and draw conclusions from the problems under consideration;
- Experience of creative activity: ability to identify problems, solve them, and form hypotheses;
- Individual work: work with educational and methodological, scientific, auxiliary domestic and foreign literature on the issues under consideration, ability to obtain information from various sources (traditional, special periodicals, mass media, Internet, etc.).

The test survey can be conducted on one or more content modules. In the latter case, the points awarded to the Applicant for answering the test questions are divided between the content modules.

The coursework is subject to defense by the applicant in classes that are assigned additionally.

The coursework can be completed in various forms. In particular, applicants can submit their application in the form of an abstract. The abstract must have a volume of 18 to 24 A4 pages of text (Times New Roman, font size 14, spacing 1.5), including a plan, the structure of the central part of the text following the plan, conclusions, and a list of literature compiled following DSTU 8302:2015. The abstract can also include a dictionary of key concepts related to the topic. At the same time, the coursework can be completed in various forms, for example, as a didactic project or a PowerPoint presentation. In this case, the volume of work is determined individually, depending on the topic.

The literature recommended for completing the coursework is presented in this work program. In electronic form, it is posted on the KNUBA Educational website, on the department page.

Also, as part of the coursework, at the teacher's decision, the applicant's participation in an international or all-Ukrainian scientific and practical conference with the publication in the conference materials of the abstracts of a speech (report) on one of the topics related to the content of the educational component, or the publication of an article on one of such topics in other scientific journals, may be counted.

The coursework text is submitted to the teacher no later than two weeks before the start of the exam session. The teacher has the right to require the Applicant to revise the coursework if it does not meet the established requirements.

The results of the current control are entered into the work log. A positive assessment of the current performance of the Applicants, in the absence of missed and uncompleted practical classes, and positive grades for the course, is the basis for admission to the final form of control. Points for classroom work are calculated in cases of absences.

The final control is carried out during the credit session, taking into account the results of the current and module controls. During the semester, the results of passing all types of academic work, as outlined in the credit structure, are taken into account.

The evaluation is carried out on a 100-point scale.

Distribution of points for the discipline with a form of exam

Current assessment			Exam	Total points
Units		Coursework		
1	2			
25	***25***	***30***	***20***	***100***

Coursework grading scale

National scale grade	Points	Criteria
excellent	30	excellent performance (disclosure of the topic, references, and citation of modern scientific sources (no older than 2021), **compliance with integrity standards**)
	28	excellent performance with a small number of performance errors (disclosure of the topic, references, and citation of modern scientific sources (most of which are not older than 2021), **compliance with integrity standards**)
good	25	above average performance with several errors (disclosure of the topic within the scope of the work and tasks, references and citation of modern scientific sources (including those not older than 2021), **compliance with integrity standards**)
	22	performance with a certain number of errors (disclosure of the topic within the scope of the object and tasks of the work, availability of references and citations of scientific sources, **compliance with integrity standards**)
satisfactorily	20	The work meets the minimum criteria for errors (disclosure of the topic mainly within the scope of the work, the presence of a conceptual framework for the job, the presence of at least five references and citations of scientific sources, and **compliance with integrity standards**)

Grading scale: national and ECTS

Total points for all types of learning activities	ECTS grade	National scale grade
90-100	**A**	***excellent***
82-89	**B**	***good***
74-81	**C**	
64-73	**D**	***satisfactorily***
60-63	**E**	
35-59	**FX**	Not accepted with the possibility of retaking
0-34	**F**	Not passed with mandatory re-study of the discipline

Conditions of admission to the final test

An applicant with a final grade of 35 to 59 points for the educational component is assigned an additional credit session. In this case, he must complete additional tasks determined by the teacher.

A candidate who has not fulfilled the requirements of the work program for the content modules is not allowed to take the final test. In this case, he must complete an additional task on the topics covered in the relevant content modules, as determined by the teacher, between the primary and extra sessions.

The applicant has the right to protest the results of the control (appeal). The rules for submitting and considering an appeal are outlined in the internal documents of the KNUCA, which are posted on the KNUCA website and communicated to applicants before the start of the educational component.

Methodological support of the discipline

Textbooks:

1. Giloi, W. (1978). Interactive computer graphics: data structures, algorithms, languages. Prentice-Hall.
2. Preparata, F. P., & Shamos, M. I. (1985). Computational geometry. Springer New York. https://doi.org/10.1007/978-1-4612-1098-6
3. Marschner, S., Shirley, P., Ashikhmin, M., Gleicher, M., Hoffman, N., Johnson, G., Munzner, T., Reinhard, E., Thompson, W. B., Willemsen, P., & Wyvill, B. (2021). Fundamentals of computer graphics. A K Peters/CRC Press. https://doi.org/10.1201/9781003050339
4. Szeliski, R. (2022). Computer vision. Springer International Publishing. https://doi.org/10.1007/978-3-030-34372-9
5. Vince, J. (2022). Mathematics for computer graphics. Springer London. https://doi.org/10.1007/978-1-4471-7520-9.

Information resources:

1. http://library.knuba.edu.ua
2. http://org2.knuba.edu.ua