NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Machines and equipment design department

APPROVED
Faculty of Design and Engineering
"___" June 2025

COURSE SYLLABUS

Mechatronic Systems of Robots and UAVs

Field of knowledge: 13 "Mechanical Engineering"
Specialty: 133 "Industrial Engineering'
Educational program "Industrial Engineering"
Faculty of Design and Engineering
Developer: Associate Professor, Department of Machine and Equipment Design
PhD in Technical Sciences, Associate Professor Viktor KRUSHELNYTSKYI

Kyiv – 2025

Course description: Mechatronic Systems of Robots and UAVs
(title)

The course **"Mechatronic Systems of Robots and UAVs"** is aimed at developing knowledge of the principles of designing modern mechatronic systems used in robotics and unmanned aerial vehicles (UAVs). The course covers the fundamentals of AC drives, principles of frequency-controlled drives, the structure and tuning of PID controllers, as well as the processing of signals from UAV sensors. Considerable attention is given to configuring frequency converters, understanding the operation of digital-to-analog converters (DACs), generating control signals for drive control, and processing sensor signals.

Field of knowledge, Specialty, Education program, Degree	
Degree	*Bachelor*
Specialty	*133 "Industrial Engineering"*
Education program	*Industrial Engineering*
Educational and Professional Programme	*Robotics and robotic systems and complexes*
Course Description	
Type	*Elective*
General volume of hours	*120*
Number of credits ECTS	*4*
Number of modules	*2*
Course project	-
Control form	*Exam*
Course indicators for full-time and part-time forms of higher education	
Year of preparation	*4*
Semester	*8*
Lectures	*13 h.*
Practical classes	-
Lab classes	*13 h.*
Self-study	*94 h.*
Individual work	-
Number of weekly classroom hours for full-time studies	2 h.

1. Purpose, Competencies, and Learning Outcomes of the Course

The purpose of the course **"Mechatronic Systems of Robots and UAVs"** within the specialty 133 "Industrial Engineering" is to provide students with theoretical knowledge and practical skills in the integration of mechanical, electronic, and software components for the creation of complex and functional mechatronic systems.

Acquired Competencies:

Integral Competence (IC): The ability of a person to solve complex specialised tasks and practical problems in a certain field of professional activity or during the learning process, which involves the application of certain theories and methods of relevant sciences and is characterized by complexity and uncertainty of conditions.

General Competencies (GC):

GC1. Ability for abstract thinking.

GC3. Ability to plan and manage time.

GC4. Ability to search, process, and analyze information from various sources.

GC7. Ability to communicate in a foreign language.

GC8. Ability to act socially responsibly and consciously.

GC9. Ability to motivate people and move towards a common goal.

GC10. Skills in using information and communication technologies.

GC11. Ability to work in a team.

GC13. Ability to preserve and multiply moral, cultural, and scientific values and achievements of society based on understanding the history and regularities of development of the subject area, its place in the general system of knowledge about nature and society, and in the development of society, technology, and engineering; use different types and forms of physical activity for active rest and a healthy lifestyle.

Special (Professional) Competencies (SC):

PC1. Ability to apply typical analytical methods and computer software tools to solve engineering problems in mechanical engineering, effective quantitative methods of mathematics, physics, engineering sciences, and appropriate computer software for solving engineering tasks in mechanical engineering.

PC3. Ability to evaluate and ensure the quality of performed work.

PC4. Ability to implement engineering developments in mechanical engineering considering technical, organizational, legal, economic, and environmental aspects throughout the entire lifecycle of the machine: from design, construction, operation, maintenance, diagnostics, to disposal.

PC6. Ability to assess the technical and economic efficiency of typical systems and their components based on analytical methods, analog analysis, and use of available data.

Program Learning Outcomes (LO):

LO1. Knowledge and understanding of the fundamentals of technological, fundamental, and engineering sciences underlying mechanical engineering in the respective field.

LO2. Knowledge and understanding of mechanics and mechanical engineering and their development prospects.

LO3. Knowledge and understanding of automatic control systems for objects and processes in mechanical engineering, and skills in their practical application.

LO4. Ability to perform engineering calculations to solve complex tasks and practical problems in mechanical engineering.

LO7. Prepare production and operate products using automatic lifecycle support systems.

LO8. Understand relevant methods and have skills in designing typical units and mechanisms according to the assigned task.

LO9. Select and apply necessary equipment, tools, and methods.

LO11. Communicate fluently with the engineering community orally and in writing in both the national and foreign languages.

LO13. Understand the structures and functions of enterprises in mechanical engineering.
LO14. Develop machine parts and assemblies using computer-aided design (CAD) systems.

2. Program and Structure of the Course

Titles of Content Modules and Topics	Number of hours						
	full-time						
	total	including					
		l	p	lab	ind	self-st.	weeks
Module 1. Mechatronic Systems with AC Drive							
Topic 1. AC Drive	18	2	-	2	-	14	1-2
Topic 2. Mechatronic Systems with Frequency-Controlled Drives	52	6	-	6	-	40	3-9
Total for module 1	70	8	-	8	-	54	-
Module 2. PID Controller and Digital Signal Processing							
Topic 3. PID Controller	20	2	-	2	-	16	10-11
Topic 4. Signal Processing from UAV Sensors	30	3	-	3	-	24	12-13
Total for module 2	50	5	-	5	-	40	-
Total hours	120	13	-	13	-	94	-

3. Lecture Topics

№	Topic Title	Hours
1	AC Drive	2
2	Mechatronic Systems with Frequency-Controlled Drives	6
3	PID Controller	2
4	Signal Processing from UAV Sensors	3

4. Laboratory Topics

№	Topic Title	Hours
1	Frequency-controlled drive	2
2	Digital-to-analog converter	2
3	Control signal formation using DAC	2
4	External control of the frequency converter	2
5	PID controller	2
6	Signal processing from UAV sensors	3

5. Self-preparation works

№	Topic title	Hours
1	Use of mechatronic robot systems for automated manufacturing and industrial automation	14
2	Complementary filter	13
3	Mahony filter	13
4	PID controller tuning methods	16
5	Visual monitoring systems for UAVs using computer vision	14
6	Use of artificial intelligence and neural networks to enhance the functionality of mechatronic robot systems	14
7	Development of algorithms for autonomous navigation of unmanned aerial vehicles	10

6. Methods and tools for assessing learning outcomes: Assessment is conducted through modular tests, defense of laboratory works, and the final evaluation of learning outcomes is carried out in the form of an exam.

7. Teaching methods

The instruction of this discipline involves the use of verbal, visual, and practical teaching methods, as well as self-preparation work.

8. Assessment of learning outcomes

Students' knowledge is evaluated on a 100-point scale, which is then converted into the national grading system in accordance with the current "Regulations on Exams and Tests at NUBiP of Ukraine."

8.1. Distribution of Points by Types of Educational Activities

Type of education activity	**Learning outcomes**	**Evaluation**
Module 1. Mechatronic Systems with AC Drive		
Laboratory work 1	Learning outcomes (LOs) specified by the curriculum include knowing the principles of operation of AC electric drives, frequency-controlled drives as part of mechatronic systems, generating analog control signals using digital-to-analog conversion, as well as implementing external control schemes for frequency converters.	**20**
Laboratory work 2		**20**
Laboratory work 3		**20**
Self-preparation work for module 1		**30**
Module 1 test		**10**
Total for Module 1	-	**100**
Module 2. PID Controller and Digital Signal Processing		
Laboratory work 4	The learning outcomes (LOs) specified by the curriculum include understanding the design principles and tuning of PID controllers, methods of processing signals from unmanned aerial vehicle (UAV) sensors, including filtering, normalization, and data transformation for use in control systems.	**20**
Laboratory work 5		**20**
Laboratory work 6		**20**
Self-preparation work for module 2		**30**
Module 2 test		**10**

	Special emphasis is placed on the practical application of controllers and sensor information in mechatronic systems.	
Total for Module 2	**-**	**100**
Education work	**0,7*(M1*70 + M2*50)/120 ≤ 70**	
Exam	**30**	
Total for the course	**(Education work+Exam) ≤ 100**	

8.2. Higher Education Student Knowledge Assessment Scale

Learner's assessment, points	Grade according to the national grading system (exams/credits)
90 – 100	Excellent
74 – 89	Good
60 – 73	Satisfactorily
0 – 59	Unsatisfactorily

8.3. Evaluation policy

Deadline and re-examination policy:	Papers submitted after the deadline without good reason are given a lower grade. Modules can be retaken with the permission of the lecturer if there are good reasons (for example, illness)
Academic Integrity Policy:	Cheating during tests and exams is prohibited (including using mobile devices). All papers and essays must have correct text references to the literature used
Attendance Policy:	Class attendance is mandatory. For objective reasons (for example, illness, international internship), training can be carried out individually (online, in agreement with the dean of the faculty)

9. Educational and Methodological Support:

1. Крушельницький, В. В. *Електронний курс "Мехатронні системи роботів і БПЛА"* [Electronic resource]. Навчально-інформаційний портал НУБіП України. https://elearn.nubip.edu.ua/course/view.php?id=4220
2. Ловейкін, В. С., Ромасевич, Ю. О., & Крушельницький, В. В. (2020). *Мехатроніка: навчальний посібник*. Київ.
3. Артюх, О. М., Дударенко, О. В., Сосик, А. Ю., & Щербина, А. В. (2020). *Конспект лекцій з дисципліни «Основи мехатроніки»* (86 с.). Запоріжжя: НУ «Запорізька політехніка».
4. Михайлов, Є. П., & Лінгур, В. М. (2019). *Навчальний посібник з дисципліни "Маніпулятори та промислові роботи" : для студентів бакалаврів*. Одеса: Одеський національний політехнічний університет.
5. Цвіркун, Л. І., & Грулер, Г. (2017). *Робототехніка та мехатроніка: навч. посіб.* (3-тє вид., переробл. і доповн.). Дніпро: Національний гірничий університет.

10. Recommended sources of information

1. Орловський, Б. В. *Мехатроніка в галузевому машинобудуванні* [Electronic resource]. https://dut.edu.ua/uploads/l_1830_80162251.pdf
2. Microchip Technology. (2009). *12-bit digital-to-analog converter with EEPROM memory in SOT-23-6* [Electronic resource]. https://ww1.microchip.com/downloads/en/devicedoc/22039d.pdf
3. Mitsubishi Electric. *FR-F700 instruction manual* [Electronic resource]. https://dl.mitsubishielectric.com/dl/fa/document/manual/inv/ib0600177eng/ib0600177engf.pdf
4. Arduino. *Tutorials* [Electronic resource]. https://docs.arduino.cc/tutorials/
5. Tinkercad. *Official guide to Tinkercad Circuits* [Electronic resource]. https://www.tinkercad.com/blog/official-guide-to-tinkercad-circuits
6. Arduino. *Arduino IDE* [Electronic resource]. https://www.arduino.cc/en/software/
7. Arduino. *Arduino language reference* [Electronic resource]. https://www.arduino.cc/reference/en/
8. Microchip Technology. (n.d.). *ATmel ATmega328P* [Electronic resource]. https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf