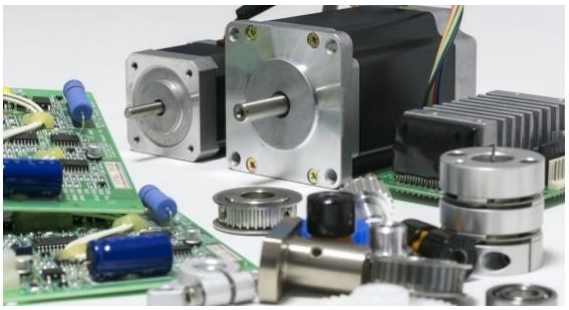
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-27] MECHATRONICS



Work program of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics, Automation, and Electronic Communications
Specialization	172 - Electronic Communications and Radio Engineering
Educational program	All educational programs
Discipline status	Elective (F-catalog)
Form of higher education	Full-time
Year of training, semester	Available for selection starting from the 2nd year, fall semester
Scope of the discipline	4 credits (Lectures 18 hours, Practical classes 36 hours, Laboratory work 36 hours, Independent work 66 hours)
Semester Control/control measures	Credit
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian
Information about the course leader/teachers	Lecturer: Shulga A. V., Independent work: Shulga A. V.
Course location	https://do.ipo.kpi.ua/course/view.php?id=3677

Curriculum

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

The rapid development of mechatronics as a new scientific and technical field is due to the rapidly growing interest and high activity of specialists in the scientific, educational, and manufacturing spheres. This determines the prospects for the development of mechatronics in the 21st century as one of the key areas of modern science and technology.

Mechatronics is a branch of science and technology based on the synergistic combination of precision mechanical components with electronic, electrical, and computer components. This combination enables the design and manufacture of qualitatively new mechanisms, machines, and systems with intelligent control and functional movements.

The goal of mechatronics is to create intelligent machines and technical systems for various purposes, taking into account the physical processes that occur and lead to the creation of qualitatively new functions, properties, and characteristics; to provide students with a comprehensive knowledge of mechatronic and robotic systems; mastering the methodology of designing technological processes using mechatronic and robotic systems.

The subject of mechatronics is methods, processes of design and production of qualitatively new modules, complexes and machines, and on their basis – intelligent research and industrial self-governing technical systems.

The mechatronics ***method*** is based on the systematic combination of separate natural science and engineering disciplines, such as precision mechanics, electrical engineering, microelectronics, computer control, and computer science at all stages of the product life cycle, starting with marketing and design and continuing through the stages of implementation (production), operation, and disposal.

The discipline provides the formation of the following competencies:

- The ability to perform computer modeling of devices, systems, and processes using universal application software packages (PC 4);
- Ability to implement promising technologies and standards (PC 8).
- Ability to accept and master new equipment in accordance with current standards (PC 9);
- Ability to assess the place and advantages of introducing elements of intelligent technologies and intelligent radio electronics into various fields of human activity (PC 18).

Program learning outcomes:

- Apply understanding of the means of automation of design and technical operation of telecommunications and radio engineering systems in professional activities (PLO 15);
- Selecting the configuration, structure, main components, and elements of radio-electronic equipment depending on its purpose (PLO 29)

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

Prerequisites for mastering the introductory discipline:

the student must ***know:*** higher mathematics, computer science, engineering and computer graphics, fundamentals of metrology, introduction to the specialty.

3. Content of the discipline

Introduction. Areas of application of mechatronic systems

Topic 1. Sensors of mechatronic systems

1.1. Classification of sensors

1.2. Basic characteristics of sensors

1.3. Types of sensors and principles of their operation

1.3.1. Electrical contact sensors

1.3.2. Potentiometric sensors

1.3.3. Tensometric sensors

1.3.4. Piezoelectric sensors

1.3.5. Hall sensor

1.3.6. Capacitive sensors

1.3.7. Optical sensors

1.3.8. Electromagnetic sensors

1.3.9. Ultrasonic sensors

1.3.10. Temperature sensors

1.3.11. Humidity sensors

1.4. "Intelligent" sensors

Topic 2. Drives and drive control in mechatronic systems

2.1. Drive requirements

2.2. Hydraulic and pneumatic drives

2.3. Electric drives. Basic concepts and classification

2.4. Direct current electric motors

2.4.1. Commutator electric motor

2.4.2. Brushless electric motor

2.4.3. Stepper electric motor

2.5. AC electric drive 2.5.1. AC electric motors

2.5.2. Frequency scalar control of an asynchronous motor

2.5.3. Frequency vector control of an asynchronous motor

2.6. Motion modules in mechatronic systems

2.6.1. Electromechanical motion modules

2.6.2. Mechatronic motion modules

2.6.3. Intelligent motion modules

2.6.4. Servo drives

2.6.5. Linear actuator

Topic 3. Microcontrollers of mechatronic systems

3.1. The historical development of microcontrollers and their applications in modern manufacturing

3.2. The main components of a microcontroller

3.3. Programmable logic controllers

3.4. Microprocessor architecture

3.5. Characteristics of microcontrollers

3.6. Computers in mechatronic systems

3.6.1. Computer as a controller

3.6.2. Computers for communication with operators

3.6.3. Industrial computers

3.7. Input/output devices

Topic 4. Methods of organizing interaction in mechatronic systems

4.1. Basic functions, structure, and parameters of a computer control system

4.2. Methods of organizing the computing device of a computer control system

4.3. Options for organizing the interface part of a computer control system

4.4. Data transfer between mechatronic devices

4.4.1. General information about industrial networks

4.4.2. Wired networks

4.4.2.1. RS-232, RS-422, and RS-485 interfaces

4.4.2.2. CAN interface

4.4.2.3. Serial peripheral interface SPI

4.4.2.4. I^2C interface

4.4.2.5. UART interface

4.4.3. Wireless networks

4.4.3.1. Areas of application and advantages of wireless networks

4.4.3.2. Problems with wireless networks and ways to solve them

4.4.3.3.Bluetooth

4.4.3.4. Wi-Fi

Topic 5. Fundamentals of control in mechatronic systems

1.1. Hierarchy of control systems in mechatronics

1.2. Designing control systems for mechatronic objects

1.3. Basic concepts of control theory

1.4. Stability of a dynamic system

1.5. Classification of automatic control tasks

4. Teaching materials and resources

Basic literature

1. Loveikin V.S., Romasevich Yu.O., Krushelnitsky V.V. Mechatronics. Textbook. – Kyiv, 2020. – 404 p.

2. Modern electromechanical complexes and systems: textbook / T. P. Pavlenko, V. M. Shavkun, O. S. Kozlova, N. P. Lukasheva; Kharkiv National University of Municipal Economy named after O. M. Beketov. – Kharkiv: O. M. Beketov National University of Urban Economy, 2019. – 116 p.

3. Pavlenko I.I., Mazhara V.A. Robotic technological complexes. Monograph – Kropyvnytskyi: KOD Publishing House. 2019. – 382 p.

4. Tsvirkun L.I. Robotics and Mechatronics: Textbook. / L.I. Tsvirkun, G. Gruhler; edited by L.I. Tsvirkun; Ministry of Education and Science of Ukraine, National Mining University. – 3rd ed., revised and supplemented. – Dnipro: NGU, 2017. – 224 p.

5. Pavlenko I.I., Godunko M.O. Robot Gripping Devices. Monograph – Kropyvnytskyi: KOD Publishing House. 2020. – 386 p.

Supporting

Information resources

https://fluidsim.software.informer.com/

https://www.festo-didactic.com

Educational content

5. Methodology for mastering the academic discipline (educational component)

Lectures

No	Lecture topic and list of main questions (list of teaching aids, references to literature, and assignments for independent study)
1	*Introduction. Areas of application of mechatronic systems Literature:* 1-4 sources from the list of teaching materials *Assignments for independent study:* • Review the lecture materials

2	*Topic: "Sensors in mechatronic systems"* • *Classification of sensors* • *Basic characteristics of sensors* • *Types of sensors and principles of their operation* • *Electrical contact sensors* • *Potentiometric sensors* • *Tensometric sensors* • *Piezoelectric sensors* • *Hall sensor* • *Capacitive sensors* • *Optical sensors* • *Electromagnetic sensors* • *Ultrasonic sensors* • *Temperature sensors* • *Humidity sensors* • *"Intelligent" sensors Literature:* 1-4 sources from the list of educational materials *Assignments for independent study:* Review lecture materials
3	*Topic: "Drives and drive control in mechatronic systems"* • *Requirements for drives* • *Hydraulic and pneumatic drives* • *Electric drive. Basic concepts and classification* • *Direct current electric motors* • *Commutator electric motor* • *Brushless electric motor* • *Stepper electric motor* • *AC electric drive* • *AC electric motors* • *Frequency scalar control of an asynchronous motor* • *Frequency vector control of an asynchronous motor* • *Motion modules in mechatronic systems* • *Electromechanical motion modules* • *Mechatronic motion modules* • *Intelligent motion modules* • *Servo drives* *Linear actuator* *References:* 1-4 sources from the list of educational materials *Assignments for independent study:* Review lecture materials
4	*Topic: "Microcontrollers of mechatronic systems"* • *Historical development of microcontrollers and their application in modern manufacturing* • *Main components of a microcontroller* • *Programmable logic controllers* • *Microprocessor architecture* • *Microcontroller characteristics* • *Computers in mechatronic systems* • *Computer as a controller* • *Computers for communication with operators* • *Industrial computers* *Input/output devices* *References:* 1-4 sources from the list of educational materials *Assignments for independent study:* Review lecture materials

5	*Topic: "Methods of organizing interaction in mechatronic systems"* • *Basic functions, structure, and parameters of a computer control system* • *Ways of organizing the computing device of a computer control system* • *Options for organizing the interface part of a computer control system* • *Data transfer between mechatronic devices* • *General information about industrial networks* • *Wired networks* • *RS-232, RS-422, and RS-485 interfaces* • *CAN interface* • *Serial peripheral interface SPI* • *I2C interface* • *UART interface* • *Wireless networks* • *Areas of application and advantages of wireless networks* • *Problems with wireless networks and ways to solve them* • *Bluetooth* *Wi-Fi* *References* 1-4 sources from the list of educational materials *Assignments for independent study:* Review lecture materials
6	*Topic: "Fundamentals of control in mechatronic systems"* • *Hierarchy of control systems in mechatronics* • *Designing control systems for mechatronic objects* • *Basic concepts of control theory* • *Stability of a dynamic system* *Classification of automatic control tasks Literature:* 1-4 sources from the list of educational materials *Assignments for independent study:* Review lecture materials

Laboratory work

No	Name of laboratory work
1	CREATION OF MECHATRONIC HYDRAULIC CIRCUITS
2	CREATION OF MECHATRONIC PNEUMATIC CIRCUITS
3	CREATION OF YOUR OWN MECHATRONIC HYDRAULIC AND PNEUMATIC CIRCUITS
4	CREATION OF YOUR OWN MECHATRONIC HYDRAULIC AND PNEUMATIC CIRCUITS WITH A SPECIFIED SEQUENCE OF CYLINDERS AND MOTORS

Laboratory work is performed in SolidWorks and FluidSim

6. Independent work by students

Planned homework assignment in which it is necessary to develop a mechatronic system for a specific purpose (according to the task)

Policy and control

7. Academic discipline policy (educational component)

Rules for attending classes (both lectures and labs)

Attendance and completion of laboratory work are mandatory. If these classes are missed, they must be made up during consultations or with other groups, if available. If lectures are missed, the material must be studied independently. Lecture materials are posted on the Sikorsky platform.

Defense of laboratory work

Laboratory work is defended at the beginning of the next class. Students receive two grades. The first is for the correctness of the results obtained and the completion of the protocol. The second is for the defense (passing the test on the Sikorsky platform).

Defense of homework assignments

Homework assignments are completed independently by each student. Students receive two grades. The first is for the correctness of the work and its presentation. The second is for the defense (passing the test on the Sikorsky platform).

Modular test

Modular test work is performed by each student independently after completing the entire lecture course. The student receives a grade after passing the test on the Sikorsky platform.

Incentive and penalty points and academic integrity policy

The most active students and students who complete individual assignments in an exemplary manner can receive up to 10 points towards their semester rating.

Penalty points are applied in cases where someone else's work is presented as their own, with mandatory subsequent reworking.

Deadline and resit policy

If the deadlines for submitting assignments are missed, the maximum score for the assignments is reduced by 10%.

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

The RE-27 course curriculum provides for the following rating system:

• Lectures - 18 hours; •
Module control work *1* x *15 points;*
• Laboratory work - 36 hours; (4 *labs x 15 points*) •
Home control work (*1 assignment x 25 points*).

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

Number of points	**Rating**
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

List of questions for semester assessment:

How are sensors classified according to their principle of operation?
List the main characteristics of sensors.
What is the principle of operation of potentiometric sensors?
What is the circuit for connecting strain gauge sensors?
What physical quantities can be measured using a Hall sensor?

What is an encoder and how does it work?
What types of electromagnetic sensors are there?
What types of temperature sensors are there?
What components are included in the structure of "smart" sensors?
Name the main functions of "smart" sensors.
What are the requirements for mechatronic system drives?
Find out the structure of an electric drive that is part of a mechatronic system.
What is the principle of electromagnetic torque in a DC motor?
What is a stepper motor and in which areas of mechatronics is it used?
What are the methods of regulating an asynchronous drive?
What types of frequency control of asynchronous motors exist?
Describe the structure of a frequency converter.
Explain the principle of operation of a frequency converter.
What are the main functions of modern frequency converters?
What is an intelligent mechatronic motion module?
What are the general trends in the development of microcontroller devices?
What components are included in the typical structure of a logic microcontroller?
What types of memory does a microcontroller have?
What elements are used to enter data into a microcontroller ( )?
Describe the function of a watchdog timer.
What operations does the processor perform in a microcontroller?
List the main characteristics of microcontrollers.
Give an example of a data collection device.
What are the main applications of computers in modern mechatronic systems?
What functions can a computer perform in mechatronic systems?
What are the main functions of a computer control system for a mechatronic object?
Name the ways of organizing the computing device of a computer control system.
Give examples of different types of interfaces for a computer control system for a mechatronic object.
What is an industrial network?
What types of data are you familiar with in distributed systems based on industrial networks?
Draw the correct and incorrect network topology based on the RS-485 interface.
In what cases is it desirable to use wireless data transmission in mechatronic systems?
Identify the problems inherent in wireless networks and ways to solve them.
What are the advantages and disadvantages of a Bluetooth wireless network?
What is the maximum data transfer speed in a wireless Wi-Fi network?
Name the methods for checking errors in data transmitted via a communication channel and explain their essence.
Explain the hierarchy of mechatronic control systems.
What stages can be identified in the design of mechatronic object control systems?
What is the essence of the system testing stage with a real object, and what are its features?
How is control classified depending on the values taken into account when determining the control influence?
Explain the concept of system "stability" and give examples of stable and unstable dynamic systems.
What is phase and amplitude stability margin?
Indicate how control can be classified depending on its objectives.
What are adaptive control systems and what controlled changes can occur in them?
Explain the essence of direct indicators of automatic control quality.
What integral indicators of automatic control quality are you familiar with?

Description of material, technical, and informational support for the discipline

The Mechatronics course is fully equipped with lecture halls with modern technology for conducting lectures in the form of presentations, as well as computer classrooms for practical and laboratory classes, which have the necessary software, namely SolidWorks and Fluid SIM. The course also has models that help you understand the principles of mechatronics through visual examples.

The working program of the academic discipline (syllabus):
Compiled by Shulga A. V.;
Approved by the PRE Department (Minutes No. 06/2024 dated 06/27/2024)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2024 dated 28.06.2024)