SYLLABUS OF THE ACADEMIC DISCIPLINE
«MECHATRONICS AND ROBOTICS»

DNIPRO UNIVERSITY of TECHNOLOGY 1899

Academic degree	Bachelor
Specialty	141 Electrical energetics, electrical engineering and electromechanics
Academic program	Electrical energetics, electrical engineering and electromechanics
Period of study	7 semester (13, 14 terms)
Total workload	4 ECTS credits (120 hours)
Classroom workload:	
lectures:	2 hours
laboratory:	2 hours
Language of study	English

Course page in E-learning platform of DniproTech: https://do.nmu.org.ua/course/view.php?id=3411

Teaching department Electric Drive (ED)

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1. About this course

Mechatronics is a branch of science and technology based on the synergistic combination of precision mechanics units with electronic, electrical, electromechanical and computer components that provide qualitatively new properties of modules, systems, machines and systems for intelligent control of their functional movements. This course is aimed at the ability of applicants for higher education to apply the acquired knowledge to solve engineering problems in the development, production, operation of modern mechatronic and robotic devices and systems (including intelligent ones) using world-class technologies, modern tools and software.

2. Aim and objectives

The aim of the course is to develop competencies and familiarize applicants for higher education with existing mechatronic systems and robots, robotic complexes and their management; to acquire theoretical knowledge and practical skills for analyzing the kinematics, dynamics, synthesis of robot mechanisms, taking into account the optimization of their control algorithms.

Course objectives:

- familiarization with the concept of technological process, levels of its automation;
- familiarization with the scope of mechatronic and robotic systems, the concept of their construction and terminology in mechatronics and robotics;
- study of types of technological sensors and methods of their application, familiarization with the main characteristics of sensors;
- familiarization with the elements of electropneumatic process control systems, the structure of the automated control system;
- study of the principle of operation of electropneumatic control systems;
- familiarization with the elements of electrohydroautomatic control systems for technological process, the structure of the automated control system;
- study of the principle of operation of electrohydraulic control systems;
- study of the design, principle of operation and control systems of electromechanical motors;
- familiarization with the main elements of the functional part of robots, with industrial robots and robotic complexes;
- familiarization with the kinematic analysis of the robot manipulator and learning how to use it;
- familiarization with the concept of a robotic complex, classification of robotic complexes, their layout;
- familiarization with the typical trajectories of robot manipulators within the robotic complex, their movement strategies.

3. Learning outcomes

Disciplinary learning outcomes:

- know what a technological process is, understand the organization of the mechatronic module and its control system;
- understand the principles of designing automated technological processes;
- understand the principles of designing mechatronic devices of various types, understand and analyze functional and basic control schemes;
- be able to algorithmize the technological process;
- understand the principles of controlling mechatronic systems using a programmable logic controller (PLC);
- be able to program a PLC, create projects in the software environment;
- understand the principles of designing a robot and a robotic complex (RC), be able to design a robot trajectory in the RC.

4. Course program

LECTURES

1. Properties of industrial production, the level of automation of the technological process. Technological process. Symbols of automated operations.
Basic terminology of mechatronics. Organization of the mechatronic module.
Mechatronic modules by types of converted energy. Structure of the automated control system

2. Didactic complex of FESTO company. Elements of the complex.
Portal robot station MPS Handling (H1)

MPS Joining Station (J)
MPS Sorting Station (S)
3. Electropneumomechatronic devices: symbols of elements; air preparation system; executive cylinders; distributors; control circuits of the executive cylinder
Electrohydromechatronic devices: symbols of elements; pumps, valves, hydraulic station, switchgear, control circuits; structure of the automated control system
Electromechatronic devices: motors, electric drive control systems
4. Building functional diagrams in the GRAFCET specification language to solve workflow management tasks.
Familiarization with building function diagrams for the operation of FESTO stations
5. Controlling Mechatronic Systems with Siemens PLCs, CPU 1212C: how the CPU 1212C works; performing a scan cycle; status and error indicators and switching modes; CPU memory areas; data memory, memory areas and addressing; unit of information; access to data in CPU memory areas; data types supported by S7-1200; wiring diagrams; addressing the CPU and signal module (CM) ports
6. Siemens Simatic PLC basic command system: binary logic commands (input contacts); binary logic commands (output circuits); comparison teams; arithmetic commands; data transmission commands; timers; counters; program management
7. Project creation and device configuration in the TIA Portal environment
8. Robotics: general questions; functional parts of the robot; industrial robots and robotic complex.
Kinematic analysis of the manipulator: symbolic symbols of the mechanical part of the robot; classification of kinematic pairs; coordinate systems; rules for the location of axes and the origin of kinematic pairs
Composition and classification of a robotic complex (RC).
Movement of the robot within the RC. Composition and classification of the robotic complex. Samples of location, layout of robotic systems.
Trajectories of the robot manipulator in the robotic complex.
Features of using several robots in one robotic complex.
Strategies for robotic maintenance.
Trajectories between machines as a function of the number of grippers and the organization of the production platform (stage)
Design of a robot on the example of a 3D robot.
Determining the degree of mobility of a 3D robot. Determination of the working area of a 3D robot, calculation of positioning coordinates
A sample of manipulator movement along two axes:
-Z-axis - polyharmonic trajectory;
-X-axis - linear motion with constant speed

LABORATORY WORKS

1. Study of the functionality of the portal robot MPS Handling Station (H1) using the SimuBox simulation console
2. Study of the functionality of the MPS Joining Station (J) using the SimuBox simulation console
3. Study of the functionality of the MPS Sorting Station (S) using the SimuBox simulation console
4. Study of the number systems used in computing, the rules for converting numbers from one number system to another, and the principles of programmable logic controllers

5. GRAFCET specification language. Introduction to the construction of functional diagrams for solving problems of workflow management
6. Automation of algorithms of functioning of the portal robot MPS Handling Station (H1) by means of a Siemens programmable logic controller
7. Automation of algorithms of operation of MPS Joining Station (J) by means of a Siemens programmable logic controller
8. Automation of algorithms of operation of the portal robot MPS Sorting Station (S), by means of a Siemens programmable logic controller
9. Programming the movement of a FischerTechnik 3-D robot along a designed path

5. Technical equipment and/or software

Technical means of training.

E-learning platform MOODLE, MS Teams.

During laboratory works, didactic equipment from FESTO and FischerTechnik, software packages for programming controllers from Siemens and FischerTechnik are used.

FESTO: MPS Handling, MPS Joining, MPS Sorting are for the automation of algorithms for the functioning of the portal robot station.

FischerTechnik is for programming the movement of a 3-D robot.

6. Evaluation system and requirements

6.1. The academic achievements of higher education applicants based on the results of the completion of the course will be evaluated on the scale below:

Rating	Institutional
90 – 100	Excellent
74 – 89	Good
60 – 73	Satisfactory
0 – 59	Fail

The general criteria for achieving the learning outcomes correspond to the descriptions of the 6th qualification level of the NQF.

6.2. Laboratory works are divided into four groups according to the level of complexity and are defended according to the control questions for each of the works:

Papers #1-3 are worth 5 points.

Papers #4-5 are worth 10 points.

Papers #6-8 are worth 15 points.

Paper #9 is worth 20 points.

The maximum amount of points for laboratory works is **100 points**.

6.3. The theoretical part is assessed based on the results of the control tests taken at the end of each term. An applicant receives a maximum of **100 points** for all correct answers.

6.4. Final grade for the course (on a 100-point scale):

$$FG = \frac{1}{2}SP_{lab} + \frac{1}{2}SP_t,$$

where SP_{lab} is the sum of points for laboratory works; SP_t is the sum of points for the theory.

6.5. Higher education applicants can receive a final grade in the course based on the formative knowledge progress testing, provided that the number of points gained (according to formula in §6.4) from the formative testing in the theoretical part and defense of laboratory works is at least 60 points.

If a higher education applicant has received less than 60 points in formative performance and / or seeks to improve the grade, a summative assessment (differentiated test) is conducted during control activities. If the applicant has not handed in the completed individual assignments (two laboratory works) in writing, he/she receives an unsatisfactory final grade in the course.

The differentiated test is carried out in the form of 3 levels of complexity of the complex control work, each of which includes 12 variants of tasks. Each task of the first level is worth 60 points. Each task of the second level is worth 80 points. Each task of the third level is worth 100 points.

The higher education applicant chooses the level of difficulty of the problem and solves it. Depending on the correctness of the algorithm for solving the problem and the obtained numerical values at each stage of the algorithm, the final grade is given in points not exceeding the complexity threshold.

The maximum score for the summative assessment is **100 points**.

7. Course policy

7.1. Policy on academic integrity. The academic integrity of higher education applicants is an important condition for mastering the learning outcomes of the course and obtaining satisfactory grades in formative and summative assessments. Academic integrity is based on the condemnation of the practices of cheating (writing with the involvement of external sources of information other than those authorized for use), plagiarism (reproduction of published texts of other authors without proper attribution), fabrication (inventing data or facts used in the educational process). The policy on academic integrity is regulated by the Regulation on system of prevention and detection of plagiarism at the Dnipro University of Technology (https://www.nmu.org.ua/ua/content/activity/us_documents.pdf).

If a higher education applicant violates academic integrity (cheating, plagiarism, fabrication), the assignment is graded unsatisfactory and must be repeated. In this case, the instructor reserves the right to change the topic of the assignment.

7.2. Communication policy. Applicants for higher education must have an activated corporate university email. All written questions to the instructors regarding the course should be sent to the university email.

7.3. Policy on retakes. Retakes of the summative assessment are allowed with the permission of the dean's office if there are valid reasons (e.g., sick leave).

7.4 Evaluation appeal policy. If a higher education applicant does not agree with the evaluation of his/her knowledge, he/she may appeal the grade assigned by the instructor in a prescribed manner.

7.5. Class attendance. Attendance at classes is mandatory for full-time applicants for higher education. Valid reasons for absence from classes are illness, participation in university events, and academic mobility, which must be confirmed by documents. A higher education applicant must notify the instructor either personally or through the leader of the academic group about the absence from class and the reasons for the absence.

For objective reasons (e.g. international mobility), studies may take place online with the consent of the course instructor.

8. Recommended readings

Basic:

- Ловейкін В.С., Ромасевич Ю.О., Човнюк Ю.В. Мехатроніка. Навчальний посібник. – К., 2012. - 357 с.
- Сучасні електромехатронні комплекси і системи : навч. посібник / Т. П. Павленко, В. М. Шавкун, О. С. Козлова,Н. П. Лукашова ; Харків. нац. ун-т міськ. госп-ва ім. О. М. Бекетова. – Харків : ХНУМГ ім. О. М. Бекетова, 2019. – 116 с.

Supplementary:

- Mechatronics: Principles and Applications/ Godfrey C. Onwubolu, Elsevier Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP; 30 Corporate Drive, Burlington, MA 01803, Copyright _ 2005, Godfrey C. Onwubolu. All rights reserved
- Introduction to Robotics: Mechanics and Control/John J. Craig, © 2005 Pearson Education, Inc., Pearson Prentice Hall, Pearson Education, Inc., Upper Saddle River, NJ 07458

Information resources:

Література на сайті кафедри електропривода:
https://elprivod.nmu.org.ua/ua/books/mehatronics.php